ORIGINAL ARTICLE

Integrated Approach to Food Choice Determinants and Eating Behaviour in Light of Evidence on the Genetic Control of Food Preferences

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ABSTRACT This study determines the factors associated with food preference, in the South and Non-South Indian populations, comparing and contrasting their results. 100 Indian young adults between 17-30 years of age, participated in an online questionnaire, comprising Multiple Choice, Open-ended and short answer questions. Food Choice Questionnaire (FCQ), Food Choice Motivations (FCM), and Food Choice Frequency data were also included in the survey. Mean Food Item frequency scores were also determined. Descriptive Statistical Data analyses were used to extrapolate data and obtain results. Food Choice behavior against 4 parameters, namely "Taste/Sensory Appeal", "Fussiness", "Health Concern" and "Frequency of Intake" was observed separately for each group. The hereditary pattern of the parameters across 10 different food categories was also ascertained. Food Frequency data describing the ten most commonly consumed Food Items in both South and Non-South populations were obtained. These food preferences were correlated with previous studies relating to gene regulation of dietary preferences. "Food Quality" emerged as the most significant factor affecting food choice, with 58% of respondents scoring likeliness, followed by Taste/Sensory Appeal (57%) and Food Availability (43%). The least common factors were Peer Influence (6%), Vegetarianism/Self-Identity (10%), and Animal Welfare/Ethics (10%). This is a first-of-its-kind study on the integrated effects of various factors and motivations behind Food Choices, in an Indian setting. It carries a multidimensional approach to determining the eating behavior of the Indian youth population, taking the genetic make-up of the individual into account while analyzing choice decisions.

Keywords: Food choice, Food selectivity, Food intake, Eating behavior, Nutrigenetics

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INTRODUCTION

Overview of Food Choice Determinants

The food preference of an individual depends on various factors underlying eating behavior and choice decisions. These include varying health conditions, exposure to different foods, social factors, ethics, and health benefits. Food choice decisions are complex to unfold, and drivers of eating behavior are multifactorial; understanding such determinants can help in the field of consumer nutrition and impart usefulness in preventing chronic diseases like diabetes, cancer, etc. [1]. Some factors affecting Food Selection/Choice that were previously touched upon are:

1. Studies on drivers of a food preference—taste, personal beliefs, knowledge on proper diet, pecuniary costs, ethics, cultural traditions or social influences (peer pressure, household constraints, etc.)[2], [3], [4], [5], [6], [7], [8], [27].
2. Trends in attitudes and lifestyle associated with healthy eating[2].

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3. Contextual determinants of food choices at the macro, local and social level in the fields of public health, social psychology, and consumer marketing[9].
4. Animal ethics—Peter Singer in the 1970s, stated that human interest in meat consumption does not justify animal suffering caused by miserable living conditions[10]. A vegetarian-based alternative diet can hence eliminate factory farming, bring about lower CO_2 emissions, and improve animal welfare[11]. This also gave rise to the trend of endorsing vegetarianism[12].
5. Norms and Self-identity of individuals—play a role in individuals not changing meat-based diet, despite potential ethical, environmental, and health benefits of meat avoidance[11].

Role of Genetic Determinants in Food Choice

Apart from factors like culture, convenience, and age, food choices are also reportedly shaped by genes. Genetic drivers of food preference are garnering focus in terms of personalized nutrition and health intervention[13], owing to gene variations accounting for individual differences. Though researchers acknowledge environment as a key determinant in food preferences compared to genetics[14], it is important to understand the role of genes in framing food preferences since childhood. Advances in molecular biology have enabled understanding of inter-individual differences in humans that gave researchers the tools to conduct gene association studies on a large scale. This helped to understand the role of specific gene loci in sensory perceptions, liking of foods, disliking, and overall dietary choices. The majority of studies on food liking and preferences have focused on identifying specific genes and traits associated with sensory perceptions (including smell and taste perceptions)[17].

Gene impact on eating behavior carries limited scientific investigation, owing to attribution of personal beliefs, food choice attitudes of people, and is blinded by scarce communication among the public, media, and health agencies[30]. A Genome-wide Association Study (GWAS) using Food-Choice Questionnaire established 15 genome-wide significant loci for 12 different types of foods[13]. Study on Food Use patterns of young, adult twins[28] correlated choice of food items and food groups by the study sample prone to 40% and 45% of genetic influence respectively, implying half of the variation in individual food choice is due to genetics. Rest is controlled by shared and unshared family environments, and other factors[15, 24]. Also, heritability was equal for all 24 food items[28], indicating that genes might affect not only taste perceptions[24, 32] and sensory preferences[13], but also abstinence from eating, or irregular eating[33]. Tendencies of eating patterns and diet are somewhat inherited[30]. For example, variants of the TAS2R38 gene are associated with beer, butter, and cured meat preferences[34], and TAS2R19 bitter-taste gene with grapefruit juice bitterness and liking[32]. Similarly, olfactory receptor genes also influence eating choices. For example, two Single Nucleotide Polymorphism (SNP) in the OR7D4 gene is responsible for intra-individual differences in the ability to smell androsterone which is present in the meat of pigs[35].

Genetics hence impacts the personalization of diets by nutritionists beyond what people already know, stressing the need for a customized nutrition plan, addressing the health requirements of patients. This customization is necessary as people can usually distinguish between what they prefer to eat and what they do not, but have difficulty in understanding why this happens, leading to unhealthy food choice decisions. This is evident from rising rates of obesity and diabetes. Personalized nutrition, reinforced by correlating the genetic blueprint of individuals with their food choices is both novel and demanding.

Role of Environmental Determinants

Apart from genetics, environment as a causal attribute for dietary choice and primary point of comparison has been realized[36, 16, 24]. Effects of familial surroundings on the food preference of 2 twins imply that family plays a role as the primary environment for developing food choice[24, 37, 38]. However, the influence of such shared family environments on food choice weans, as individuals turn into adults[24], and are in turn affected by their unique environments[28].

Role of Intrinsic Pleasure in Food Selection

Limitations of healthy dietary plans in recent years are that they are mostly viewed in terms of medical consideration, neglecting the intrinsic pleasure linked to foods[13]. This is in light of findings that show food choices being involved in the activation of pathways and brain areas linked to pleasure, such as the dopaminergic system and hypothalamus[18]. Hence, there is a need to change the approach in helping people modify their dietary choices, considering hedonics much more than before. The brain is known to respond to tastes differently. For example, if we eat something sweet, or umami, the brain translates this into a pleasurable experience, while anything tasting bitter will lead to avoidance[19]. This also carries a distinct evolutionary explanation, since bitterness in nature correlates with toxicity, while umami and sweetness relate to pleasure.

Food Choices Shaped by Contextual Factors

The macro-contextual understanding behind food choices is shaped by societal forces like globalization, social welfare, and urbanization that can be traced back to the onset of the industrial revolution, whereby sustained food production on a large scale and availability of dietary energy took place[20], [9]. Until then, people sustained the probability of success of harvesting crops that were influenced by seasonal variations[21]. After the industrial revolution, factory farming, technical innovations, etc. began shaping the food choices of people due to the mass-production of foods of variable tastes and sorts.

In the local context, the availability and accessibility of food outlets (e.g., Supermarkets, restaurants, etc.) in people's living environment play an important role[22]. The present study took these locally contextual factors into account. Whereas food availability refers to the thriving of food outlets in a specific area, food accessibility refers to the ease of access to a particular food outlet[23].

The social context of food choice is determined by social relationships and their influence (e.g., Family, friends, or peer groups) which can regulate, or constrain the eating patterns of people. Social facilitation is a term referring to the prevalence of increased food consumption that people might experience when eating together, rather than eating all alone[9].

Role of Animal Welfare/Ethics

Studies on food choices in the context of meat consumption were discussed concerning vegetarianism[39], [40], [41], [42], animals ethics, and self-identity of individuals on food selection.[11] Deciphering lifestyle changes through an anti-consumption lens and ethics was attempted previously by Malek and associates[39]. Sparse data on meat consumption and the rising trend of vegetarianism, particularly in India, prompted the need for identifying such factors in the study. Reasons for or against such abstaining behavior could also be ascertained[43]. A young and trendsetting population,[11] stated that a vegetarian self-identity, injunctive and descriptive social norms, and convenience most importantly determined meat intake, and not entirely ethical concerns[10], health[12], [44] or environment[45]. All works mentioned above bring home the fact that health is only one among many such determinants of food choice, and not entirely[2].

Despite monumental works, there exists a lacuna in understanding the interaction of different factors influencing the diet of the people. Most of the works are mono-disciplinary[29] carrying a narrow perspective towards disentangling a complex subject as the determination of food choice. The current study examines food choices through a wider perspective, emphasizing the most commonly reported determinants of food selecting behavior, thereby verifying the credibility of previous works. In addition, efforts to develop Multi-Dimensional measures of Food Choice have been very rare, especially in the Indian context. By carrying a first-of-its-kind approach to collate data on factors affecting food selection in an Indian setting, we attempted to address the causality of food choice through a wider lens encompassing all the above determinants.

Objectives of the Study

1. To determine the most common factors influencing Food Choices in the Indian population.
2. Understand genome-wide dissimilarities influencing the liking/disliking of foods by dividing the study population into South and Non-South category.
3. Determine restraining eating behaviors due to societal/peer influences/self-identity stimulated by personal beliefs that can change food preference in adults.
4. Extraneous variables like financial constraints, convenience, or food availability can affect food preference.
5. Attempt to measure intricacies of meat consuming or abstaining behavior or vegetarianism upon food choice that can be reinforced with genetic underpinnings.

METHODS AND MATERIAL

Survey Participants

An e-mail based questionnaire was sent to 151 Indian participants. 100 participants responded out of them (n = 100; 48 males; 52 females), and the population comprised 50 young adults each from South and Non-South Indian populations (North, Eastern, and Western populations). The participants aged from 17-30 (Mean, μ = 21.67, and standard deviation, σ = 1.6796), with a total response rate of around 66%. This can be attributed to slightly lower response rates of online questionnaires[46], [11]. Among the 100 participants, 20% indicated that they followed a strict vegetarian diet, devoid of meat. All participants gave informed consent for participation and were briefed with a small introduction about the study and guidelines on attending the survey. No participants indicated any disease/health condition that required a separate diet. All participants were unmarried (100%), and 99% of the participants indicated having more than 2 family members at home, making the student population right fit for understanding genetic, familial, and unique environmental influences on Food Preferences[11], [24]. Around 53% of the sample population comprised of females, and 47% males, consistent with a study hypothesizing a slightly higher number of female respondents due to women being more interested in the topic of nutrition[8]. 8 respondents from South and 12 respondents from Non-South populations were Vegetarians. Hence, the number of meattakers in the sample was 42 in the Southern population, and 38 in the Non-South population. In terms of education, 54% of the population reported Bachelor's or equivalent, 25% had Master's degree or equivalent, 13% had completed High School, and 8% had High School Graduate/Diploma/ Equivalent (GED). The annual income of 54% of the sample population was reported as "Almost Average", 23% as "Somewhat Above Average", 10% as "Above Average", 10% as "Somewhat Below Average", and 3% "Below Average".

Source of Data

The study sample comprised participants aged from 17-30 because:

1. This population is most prone to subjective food choices, well-educated[39], and represents the transition stage from familial influences upon food preference to developing unique taste preferences, that carry a moderate genetic basis[24].
2. Also, they are a trend-setting consumer segment, well exposed to motivations determining healthy/unhealthy eating practices, vegetarianism, animal welfare, lifestyle, and self-identity.
3. This group could have a significant rationale uninfluenced by socio-cultural beliefs and practices that influences food choice decisions among much older individuals.

Anthropometric Measures

This included the body weight and height of respondents to be calculated. Volunteers were asked to self-report Body Mass Index (BMI) Range in the questionnaire following a self-explanatory note on how to calculate. They were asked to choose any of the following options in a Multiple-Choice based question: Below 18.5 kg/m^2 (Underweight), 18.5-24.9 kg/m^2 (Normal), 25-29.9 kg/m^2 (Overweight), and 30 kg/m^2 and above (Obese).

Study Design

A multi-dimensional questionnaire titled "Assessing Food Choice and Eating Behavior" was designed using the Google Forms survey hosting tool, and a subsequent Food Choice Questionnaire (FCQ), as well as Food Frequency Questionnaire, was sent as an attachment file along with the Google Form link, through e-mail. This was in contrast to other conventional questionnaires like the restraint scale [47], 3-Factor Eating questionnaire[48], and Dutch Eating Behavior Questionnaire[49], which all accounted for only food intake restrictions instead of factors affecting food choice[2].

The online questionnaire comprised of a mix of open-ended, multiple-choice, Likert Scale, Checkboxes, Multiple-Choice Grid, and Short Answer questions. Previous studies stressed the need to address different factors relating to a food choice[2], and wider investigation of food consumption patterns[3], [5], [39], owing to the complexity of food choices behavior[29]. Respondent's views about affinity for animals, consumption/ anti-consumption of animal products, and contextual preference/abstinence of animal product alternatives were taken as well.

The Food Choice Motivations (FCM) and the Food Choice Questionnaire (FCQ) were adapted and extended from works of Steptoe and Pollard[2], and Malek and associates[39]. The Food Choice Motivations (FCM) provided in Google forms was based on a 5-point Likert Scale ("Most Likely", "Likely", "Neutral", "Unlikely" and "Most Unlikely") asking respondents to rate 13 different Factors affecting Food Choices in their daily life scenarios. These factors include Taste/Sensory Appeal, Food Availability, Health Reasons, Price Concern, Convenience, Religious/Personal Beliefs, Animal Welfare/ Ethics, Peer Influence/Social Pressure, Quality, Shift to Vegetarianism, Conformity to Preferences of Family and Peer Group, Food Accessibility, and Availability of Online Food Delivery/Takeaways.

The Food Frequency Questionnaire [Table 1] involved participants filling up a table with foods they consume every week, on average, against 5-point Likert Scale[50], [11]. The frequency table was provided with clickable checkboxes on MS Word document along with Food Choice Questionnaire, for respondents to score food items they eat, and indicate whether they consume those Food Items "Very Likely", "Likely", "Sometimes" "Rarely" or "Very Rarely". Almost all food items in the Food Frequency Questionnaire belonged at large to the 10 Food Groups undermentioned in the Food Choice Questionnaire (FCQ).

The Food Choice Questionnaire [Table 2], incorporated a Numbers/Ranking Scale, ranging from 1-10 (1 = "Most Priority" to 10 = "Least Priority") against 10 different Food Categories, namely "Cereals", "Pulses", "Fruits", "Vegetables", "Dairy Products", "Fast Foods", "Oily Foods", and a separate "Meat Products" category with 3 subsections ("Poultry", "Mutton/Beef/Pork", and "Fish/Seafood") only for Non/Semi-Vegetarians. The Vegetarian/Vegan respondents were further asked to skip the "Meat Products" Food Category and rank the remaining ones from 1-7 (with 1 = "Most Priority" and 7 = "Least Priority"). As genetics is considered one among many factors affecting food choice[31], [13], respondents were further asked to indicate whether FCQ Food Category rankings were consistent across all members in their household, for "Taste", "Fussiness", "Health Concern" and "Frequency of Intake" parameters.

Although several questions were customized and created to suit an Indian lifestyle and diet choices, most of them were improvised and adapted from previous studies[39], [51], [52], [2], [25].

Table 1: Food Frequency Questionnaire

Food Items (to be Filled by Respondents)	Food Frequency (Weekly)				
	Very Likely	Likely	Sometimes	Rarely	Very Rarely
E.g. Rice	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐

Table 2: The Food Choice Questionnaire (FCQ)

Attributes	Food Categories										Whether the Ranking Would be Consistent with the Majority of Your Family	Mention the Degree of Consistency, if Yes
	(Respond on a scale of 1-10, with 1 indicating *"most likely"* and 10 corresponding to *"least likely"*)											
								Meat Products (Only for non/semi-vegetarian)			(Respond Yes/No)	(Respond in %)
	Cereal-Based Foods	Pulses	Fruits	Vegetables	Dairy Products	Fast Foods	Oily Foods	Poultry	Mutton/ Beef/Pork /Lamb	Fish/Sea food		
Taste (example for Ranking given alongside)	7	6	4	3	5	1	2	8	10	9	Yes	20%
Fussiness (Selective Eating)												
Health Concern												
Frequency of Intake												

Data Analysis

The analytic plan for this work was unspecified earlier, and Data-driven Analysis was performed on an exploratory research basis. Descriptive Statistics was applied to measured variables for correlating obtained information on food choice. Likability of Food Groups based on 4 different attributes was assessed on a Ranking/Numbers Scale in FCQ, while 5-point Likert Scale was used for Food Choice Motivations (FCM) and Food Choice Frequency questionnaires. Mean Food Item Frequency score was also determined. The usage of food choice and choice frequency questionnaire, besides using Factor Analysis for determining food categories is well-documented in previous works[53], [54], [24]. Descriptive statistical analysis has also been previously used in studying meat avoidance behavior[39].

RESULTS AND DISCUSSION

Demographic Data

Data from the online questionnaire was interpreted using Descriptive Statistical Analysis, using Pie Charts, Clustered columns Charts, 3-D Stacked Columns, Stacked Bar charts, Scatter Plots, Line Graphs, Clustered Bars, Pareto Charts, 100% Stacked Column, and Tables [Table 3] lists "Respondent Demographics (*n* = Number of Respondents)".

Mean and standard deviations are calculated for Age and Number of Family Members at home, and the Standard Error of Mean (SEM) is calculated using the formula below:

$$\sigma_{\bar{x}} = \sigma / \sqrt{N}$$

where

Table. 3: Respondent Demographics Variables-Descriptive Statistics

Demographics	n(%), Mean and/or Standard Deviation (μ/σ)
Number of Females	52
Number of Males	48
Mean Age	100, μ= 21.69/σ=1.6796
People with Higher Income Levels	31
People with Average income levels	50
People with lower income levels	12
People who didn't disclose income levels	7
Number of Family Members at home	100, μ= 4.02/σ=1.691
Higher BMI- Overweight/Obese	17
Lower BMI/Underweight	11
People who engage in Sport Activity	76
People not Engaging in Sport Activity	24

$\sigma_{\bar{x}}$ = Standard Error of Mean (SEM)

σ = Standard Deviation, and

N = Count

Based on SEM, the margins of errors (Confidence Intervals) is determined. A confidence level of 95% (or statistical significance of 5%) is typically used to represent data.

The mean age of respondents (μ) was 21.69 and the standard deviation (σ) was 1.6796 [Figure 1]. The Standard Error of Mean (SEM) is calculated as 0.329, which determined a 95% confidence level giving a Margin of Error at 21.67±0.329 (±1.52%). Further, the Mean Age of participants was μ =21.9 for the South population, and μ =21.4 for the Non-South population.

Mean (μ) was 4.02 and standard deviation (σ) 1.691 for the Number of family members at home. The Standard Error of the Mean (SEM) was 0.169, which determined a 95% confidence level giving a Margin of Error at 4.02±0.331 (±8.24%). Around 41% of the sample population (South+ Non-South) had 4 family members at home, while 15% reported having 5 family members.

Of the South respondents, around 64% were Females, and 36% were Males, whereas for Non-South respondents, 58% were females, and 42% were Males respectively. The

Figure 1: Mean Age of Respondents (South+ Non-South)

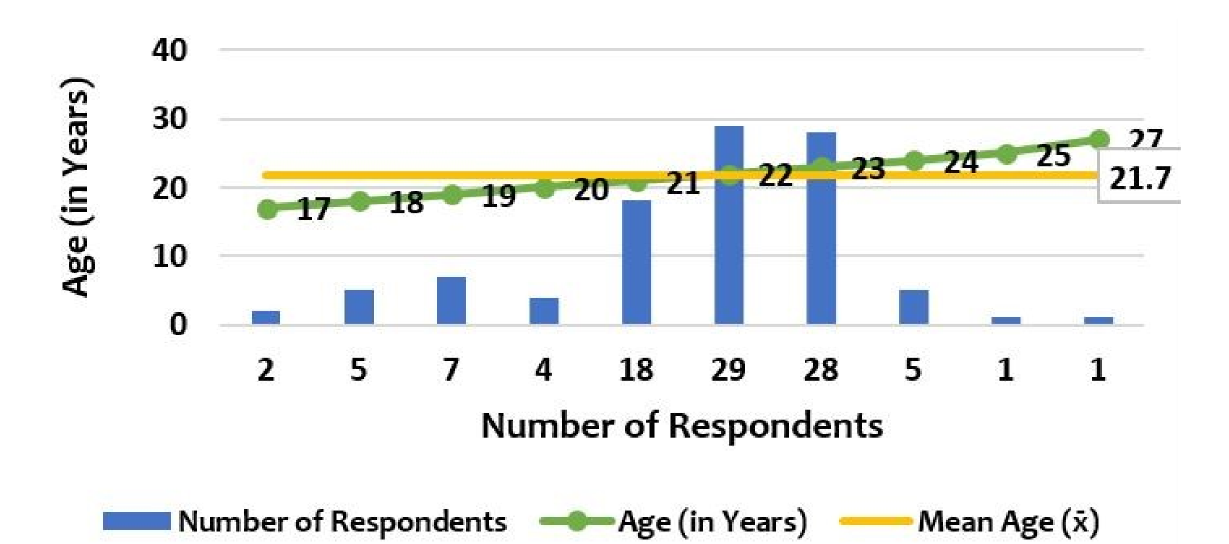
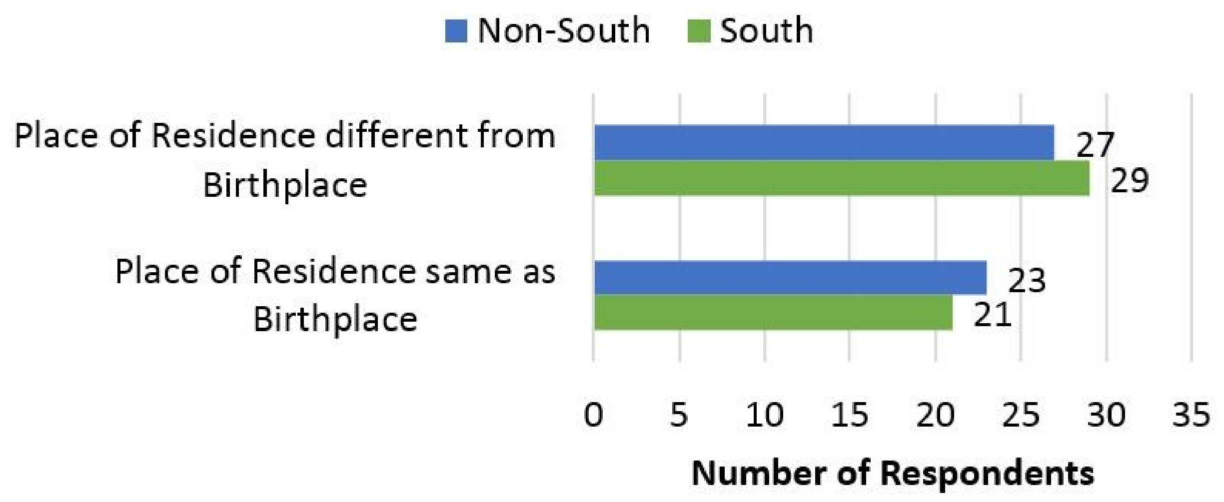


Figure 2: Respondent's Place of Birth and/or Residence



overall sample hence comprised of 53% Females, and 47% Males.

Comparing annual household income of respondents, 54% (n = 50) indicated "Almost Average", 23% (n = 22) as "Somewhat Above Average", 10% (n = 9) as "Somewhat Below Average", 10% (n = 9) as "Somewhat Above Average" 3% (n = 3) indicated "Below Average". 7 respondents who didn't want to disclose their annual income are exempted from this data. Data on respondents' Places of Residence and Birthplace are given in [Figure 2]. This data accounted for geographical variations between taste preferences among South and Non-South populations[55], [56], [57].

Additional data collected on BMI, smoking status, and Exercise Activity defined the healthiness/non-healthiness of the sample population and accounted for dietary variations. For example, there is an inverse correlation between BMI and PROP (6-n propylthiouracil) tasting gene TAS2R38, which accounts for bitter taste perception[58], [59], [55]. Allelic variants of the TAS2R38 gene include two most common forms: Proline-Alanine-Valine (PAV), and Alanine-Valine-Isoleucine (AVI) (55). PAV is also known as the taster allele. Individuals with homozygous (PAV/PAV) or heterozygous (PAV/AVI) variants perceive bitter foods like vegetables, coffee, cilantro, etc. In contrast, individuals with the homozygous (AVI/AVI) variant can tolerate bitter foods and consume without difficulty[60], [61], [62].

Diet Choices of Respondents

Among the 50 South participants, 60% (n = 30) of respondents preferred a purely Non-Vegetarian diet, including poultry, fish, seafood, beef, or pork at least once every week. 24% (n = 12) of respondents preferred a Semi-Vegetarian diet, including poultry, fish, seafood, beef, or pork less than once every week. 16% (n = 8) of respondents preferred a purely Vegetarian diet while no respondents identified themselves as vegans.

Among the 50 Non-South participants, 66% (n = 33) of respondents preferred a purely Non-Vegetarian diet,

Figure 3: Diet Choice of All Respondents

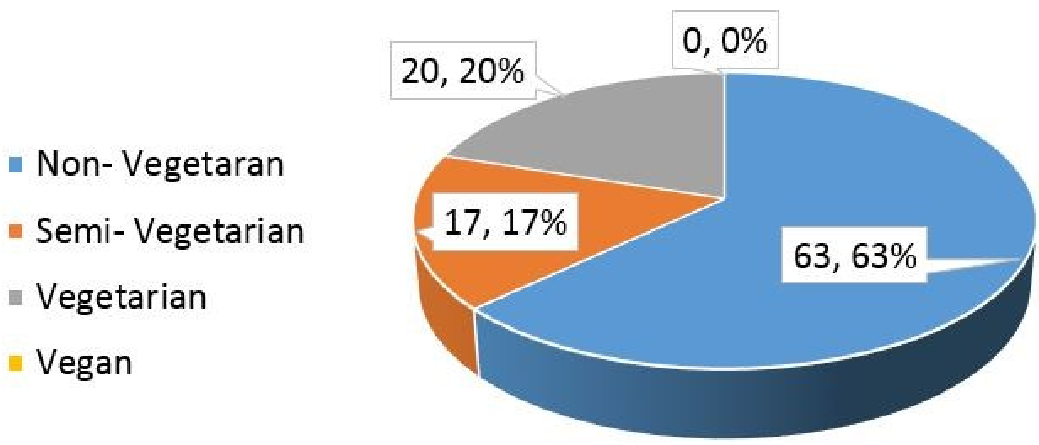


Figure 4: South and Non-South Vegetarian Respondents on "If Vegetarian/Vegan, then How Long?"

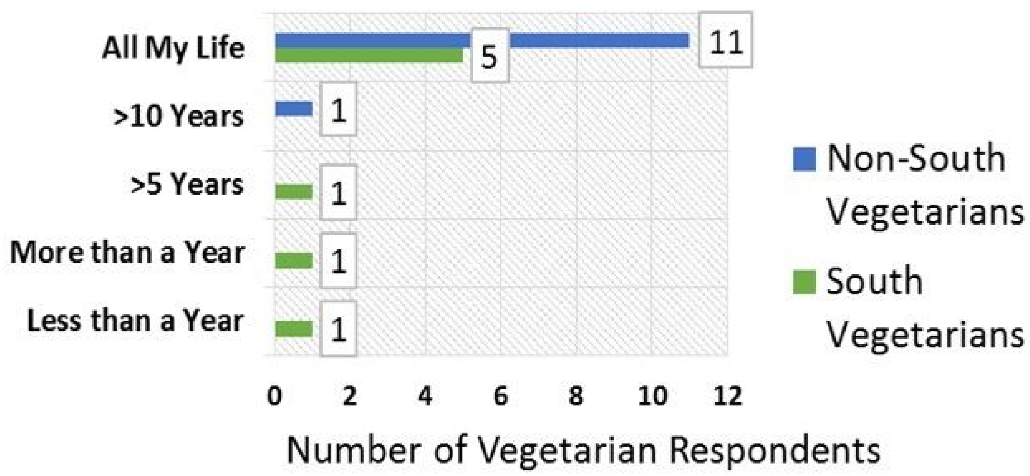
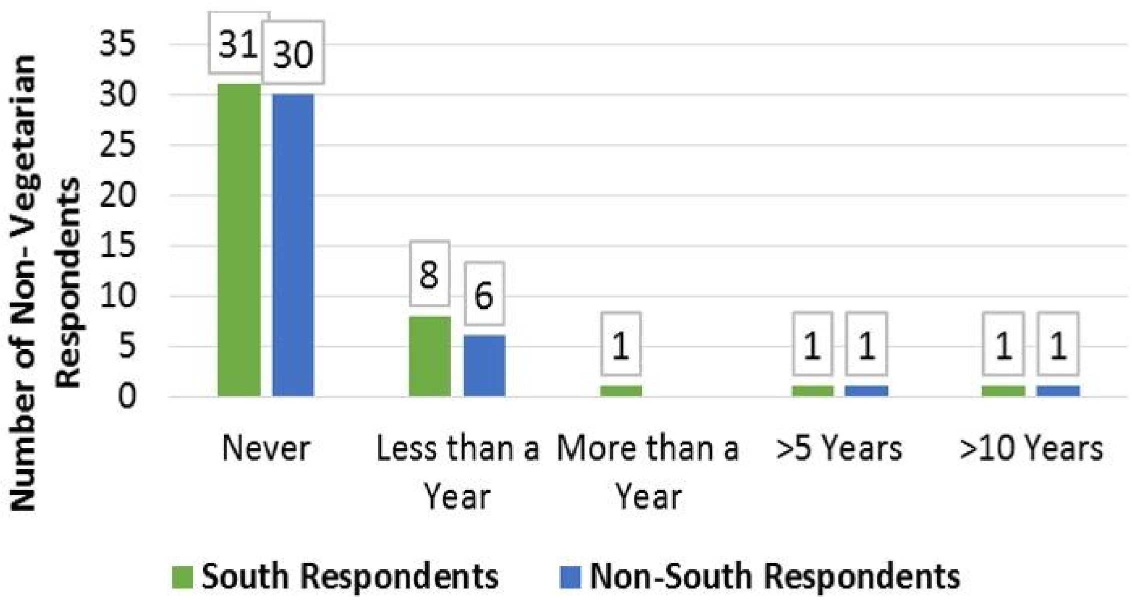


Figure 5: Non-Vegetarian Respondents on "If Vegetarian, then How Long?"



comprising of poultry, fish, seafood, beef, or pork at least once every week. 10% (n = 5) of respondents preferred a Semi-Vegetarian diet, comprising of poultry, fish, seafood, beef, or pork less than once every week. 24% (n = 12) of respondents preferred a purely Vegetarian diet while no respondents identified themselves as Vegans. The combined data on diet choices, including both South and Non-South populations, is given in [Figure 3]. Besides, data on the duration of being Vegetarian (South vs. Non-South) is given in [Figure 4], and avoidance of meat in the Non-Vegetarian sample has been given in [Figure 5].

Surprisingly, more South Non-Vegetarians answered "No" to consumption of non-meat alternatives, compared to Non-South Non-Vegetarians. The finding resembles previous studies on the high prevalence of bitter taster alleles of the gene TAS2R38 in the South population (homozygous PAV/PAV and heterozygous PAV/AVI), which accounts for less likeliness of South Indians to prefer a non-meat based vegetable diet[63], [64], [65], [55]. Assessment of preferred Food Categories according to Taste supplements this finding. Figure 9 shows the greater affinity of South respondents to prefer Meat Products (Poultry, Mutton/Beef, Fish/Seafood) in terms of Hedonic hunger, after Fast Foods and Oily Foods, compared to North respondents [Figure 7], who preferred Fruits and Vegetables as a hedonic priority, after Fast Foods and Oily Foods. Hence, taste preferences are, to a considerable extent, genetically controlled, as indicated by previous studies[66], [67], [32], [68], [69].

Animal Welfare/Ethics in the Context of Dietary Choices

Food Preferences concerning Meat Consumption and/or

Animal Welfare/Ethics being scarcely studied[39], data on whether such aspects drove meat consumption was understood in an inter-disciplinary psycho-social context[29], [70]. Though the majority of the population (58% of South respondents and 68% of North respondents) agreed that they like animals, contradictory behaviour was expressed in 58% of South and 44% Non-South populations, saying they would still consume animal products, if medically proven they are unnecessary to maintain health. Yet, only 48% of South respondents and 40% Non-South respondents answered "No" when asked whether they would stop consuming animal products if alternatives were provided. This can give insights into the development of viable alternatives to Animal products, in the coming years. This is because India is already second-lowest in terms of per-capita meat consumption rate[71] and the development of next-generation plant-based and cell-based meat alternatives has already been talked about in the scientific community **[72]**. This data was in turn, correlated with Food Choice Motivations (FCM), and it was observed that Animal Welfare and Ethics play a lesser role in driving one's Food Choices, with only 10% of respondents from the total population saying it more or less affects their Food Choices. This finding was in line with previous work on the explanation of meat avoidance pattern driven by Animal Ethics, whereby ethical benefits to animals plays a minor role in the rethinking of food preferences by the Non/Semi-Vegetarian population[39]. Previous research on the relationship between attitudes toward animal welfare and diet choice did not find any interaction effects as well[73]. The ethical perspective on food choice could hence be subjugated by social pressure to retain a meat-based diet, especially at home/familial setting, or if vegetarian diets would mean a fewer number of dishes to choose from[74], [75], [76]. The relatively minimal influence of animal welfare on one's food choices was also in disagreement with a study endorsing rising vegetarianism due to animal ethics[7].

Food Choice Motivations

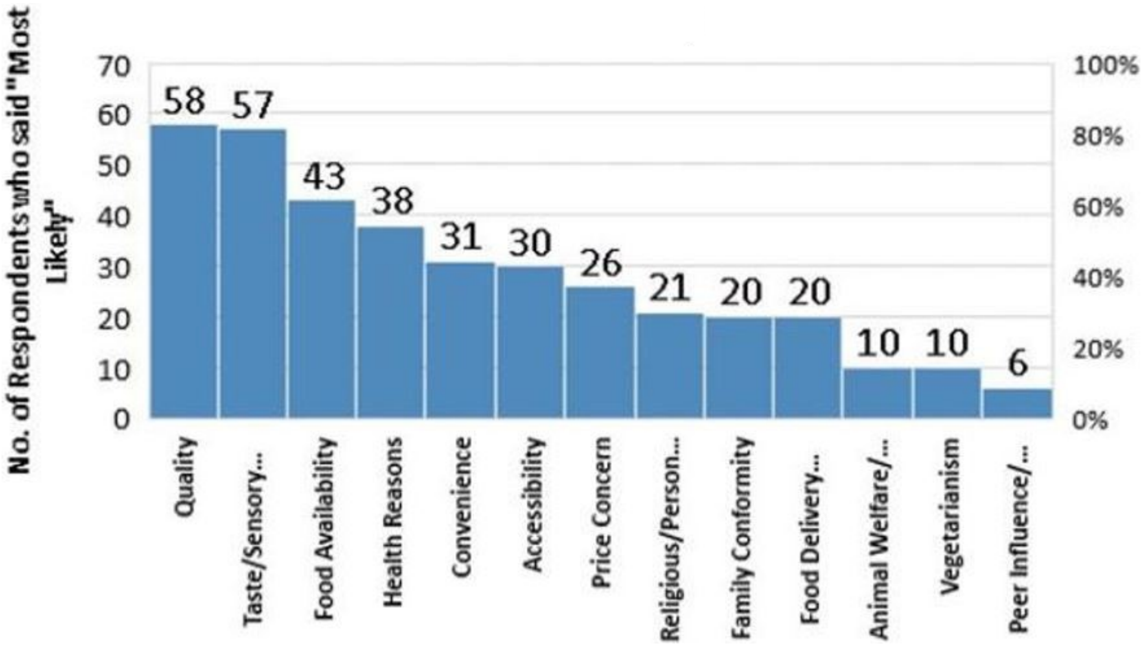
Factors most likely affecting Food Choices in the total population are given in [Table 4]. The variance of each factor (from Most Likely to Least Likely) was ascertained for the total population, and [Figure 6] represents comparative data on the factors affecting food choice from Most to Least. Similar data is obtained when contrasted between South and Non-South populations differently.

"Taste/Sensory Appeal" represented the most probable factor for driving one's food preference, in both South and Non-South populations. This finding supplements gene association studies on liking/disliking, preference, and intake of food characterized by taste/smell of foods[77], [78], [79]. "Quality" was the second likely determinant of food choice, followed by "Food Availability". The latter proves an earlier work on the availability and accessibility of food outlets, or "Consumer Nutrition Environment" affecting Food

Table 4: Factors Affecting Food Choice (South + Non-South) (n = 100)

	Most Likely	Likely	Neutral	Unlikely	Most Unlikely
Taste/Sensory Appeal	57	31	10	2	
Food Availability	43	45	11		1
Health Reasons	38	40	17	5	
Price Concern	26	38	30	2	4
Convenience	31	44	21	3	1
Religious/Personal beliefs	21	23	28	11	17
Animal Welfare/Ethics	10	32	35	11	12
Peer Influence/Social Pressure	6	25	34	8	27
Quality	58	31	11		
Vegetarianism	10	22	26	16	26
Family Conformity	20	45	18	6	11
Accessibility	30	41	19	7	3
Food Delivery Apps	20	34	29	7	10
MEAN (μ)	**28**	**34**	**22**	**7**	**11**

Figure 6: Most Likely Factors Behind Food Choice (South + Non-South)



Choices[22], [9]. "Health Reasons" was also cited as a factor, which was contradictory to previous studies placing lesser significance on Health as a food choice determinant[80], [2]. "Price Concern" was a less significant factor, which can be attributed to more than 30% of respondents declaring above-average annual household income. Figure 6 shows other factors shaping dietary preferences in decreasing order of significance. FCM covered several measurements like health, taste, sensory appeal, convenience, price concerns, etc.[2], [25], [26].

Food Choice Questionnaire

All participants ranked each Food Category from 1-10 against 4 common parameters ("Taste/Sensory Appeal", "Fussiness/ Selective Eating", "Health Concern", and "Frequency of Intake") [Table 2], followed by total scores calculated for each Food Category against all 4 parameters done to interpret FCQ data. The total population was divided into 2 categories and 4 subcategories. The Non-Vegetarian category included two sub-categories: "Non-South Non-Vegetarians" and "South Non-Vegetarians" whereas the Vegetarian category included two sub-categories: "Non-South Vegetarians" and "South Vegetarians". A ranking of 1-4 was taken as "most priority", 5-7 as "neutral priority" and 8-10 as "least priority". For Vegetarians, 1-3 indicated "most priority", 4-5 as "neutral priority" and 6-7 as "least priority". A comparison was made between North and South populations separately under each Category. Genetic similarity between participants' food choices with their family members was ascertained as a percentage at the end of each ranking. A comparison was done across all 4 parameters of FCQ separately, ie. Taste, Fussiness, Health Concern, and Frequency of Intake. Instances of the obtained results are given from [Figures 7-14] and [Tables 5-8]. Heritability studies have been done previously in adult and children twins[17], [81], [82]. However, genetic correlation in the context of familial similarity of food choices is relatively new and simple, especially when genetics is studied as one among many other factors influencing Food Choice.

In the present study, heritability in Taste preferences was reportedly 38% and 45% similar in Non-South and South Non-Vegetarians respectively in the household, whereas in the Vegetarian population, 45% Non-South and 55.7% South respondents indicated similarity.

Also, heritability in Selective eating was reportedly 55% and 46% similar in Non-South and South Non-Vegetarians respectively in the household, whereas in the Vegetarian population, 62% Non-South and 55% South respondents indicated similarity.

Heritability in Health Concern was reportedly 65.4% and 46.5% similar in Non-South and South Non-Vegetarians respectively in the household, whereas in the Vegetarian population, 78.3% Non-South and 62% South respondents indicated similarity.

Lastly, heritability in Frequency of Food Intake was reportedly 75.8% and 67% similar in Non-South and South Non-Vegetarians respectively in the household, whereas in the Vegetarian population, 77.2% Non-South and 78.3% South respondents indicated similarity.

Food Frequency Questionnaire

South and Non-South respondents scored separately, and an

Figure 7: Preferred Food Categories According to Taste (Non-South Non-Vegetarians)

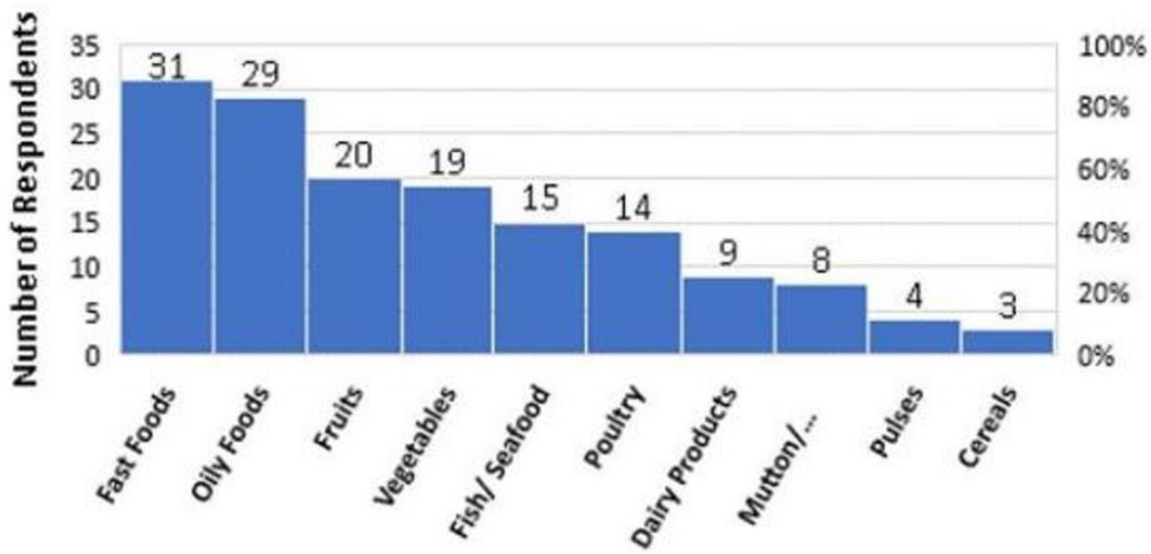


Figure 8: Whether Ranking of Food in FCQ is Consistent with the Majority of the Family (Non-South Non-Vegetarians)

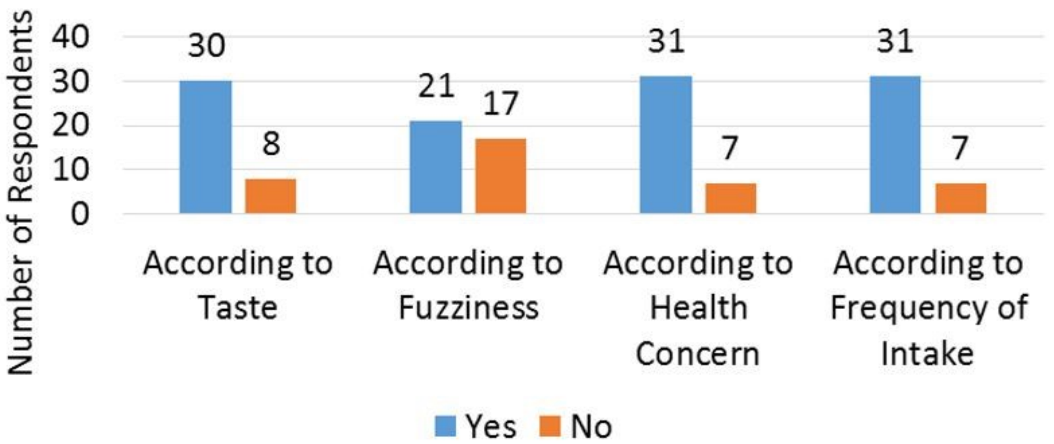


Figure 9: Prefferred Food Categories According to Taste (South Non-Vegetarians)

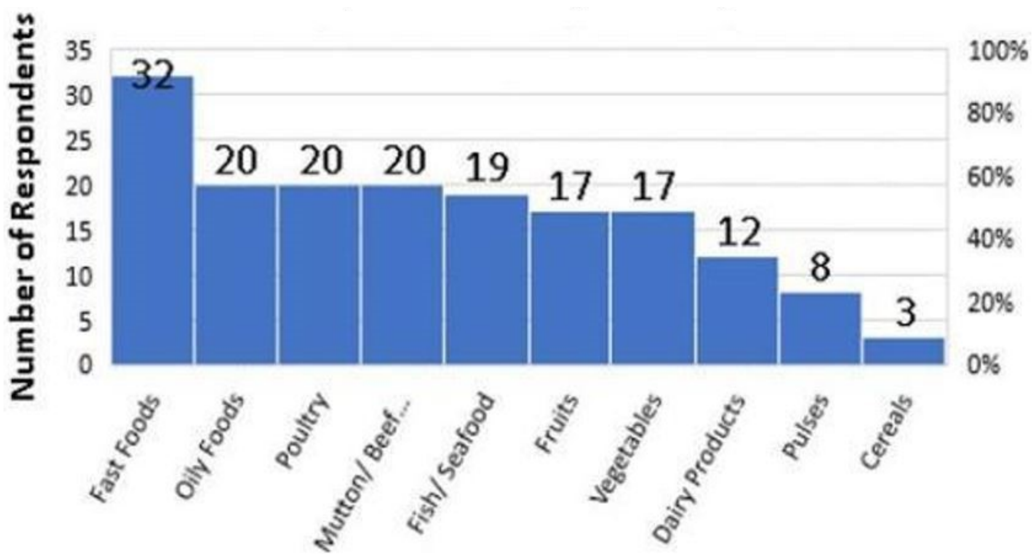


Figure 10: Whether Ranking of Foods in FCQ is Consistent with the Majority of the Family (South Non-Vegetarians)

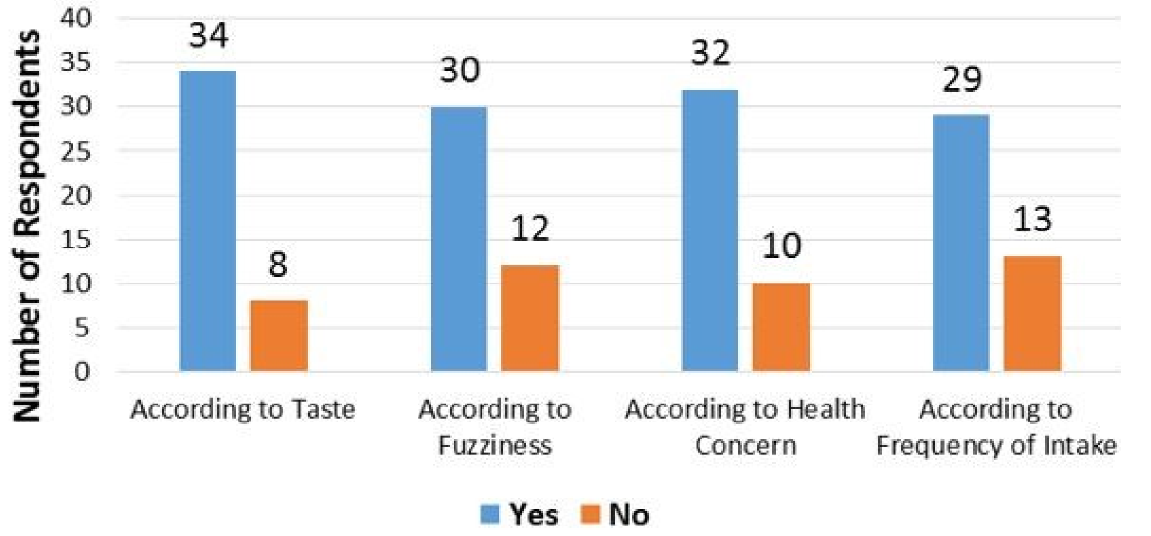


Figure 11: Health Concern about Foods (Non-South Vegetarians)

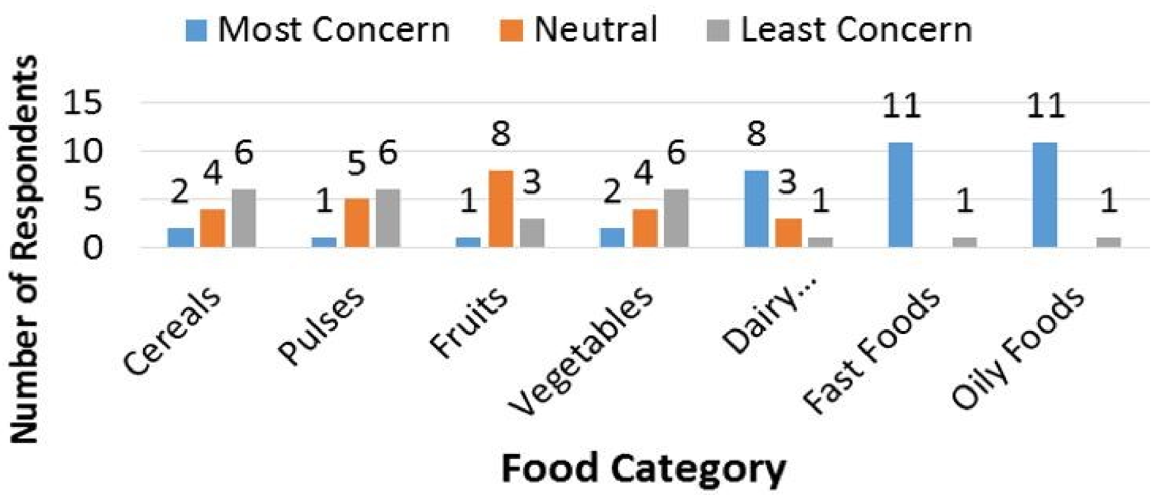


Figure 12: Whether Ranking of Foods in FCQ Consistent with the Majority of the Family (Non-South Vegetarians)

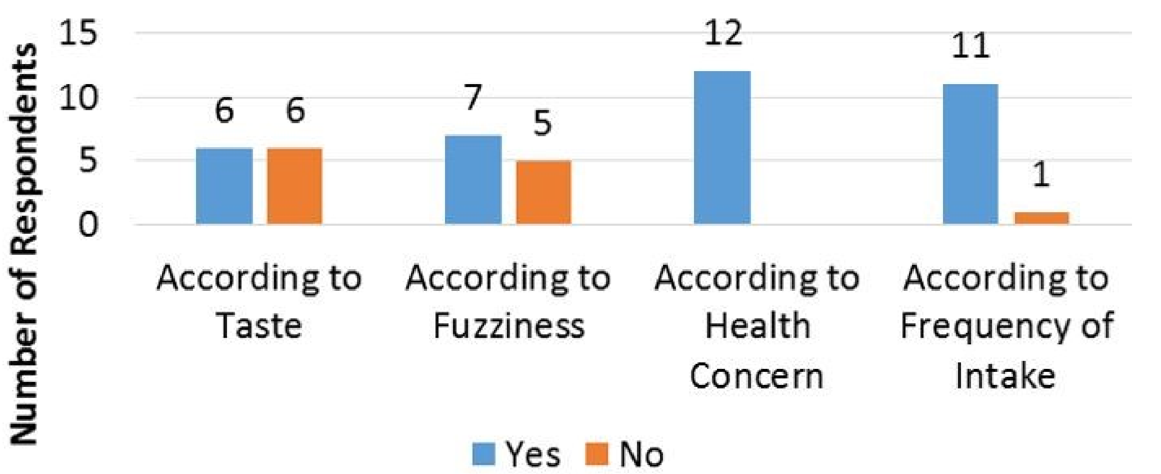


Figure 13: Fussiness among South Indians (Vegetarians)

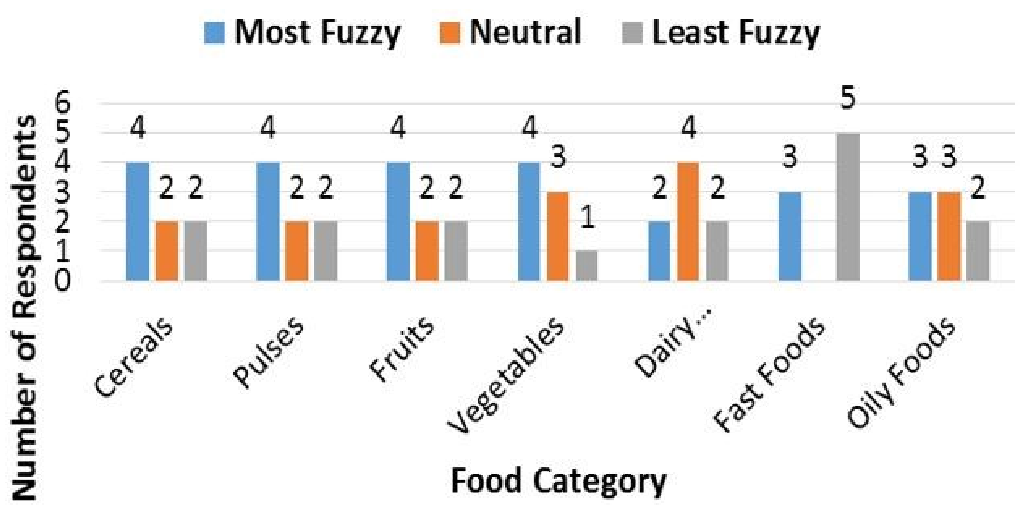


Figure 14: Whether Ranking of Foods in FCQ Consistent with the Majority of the Family (South Vegetarians)

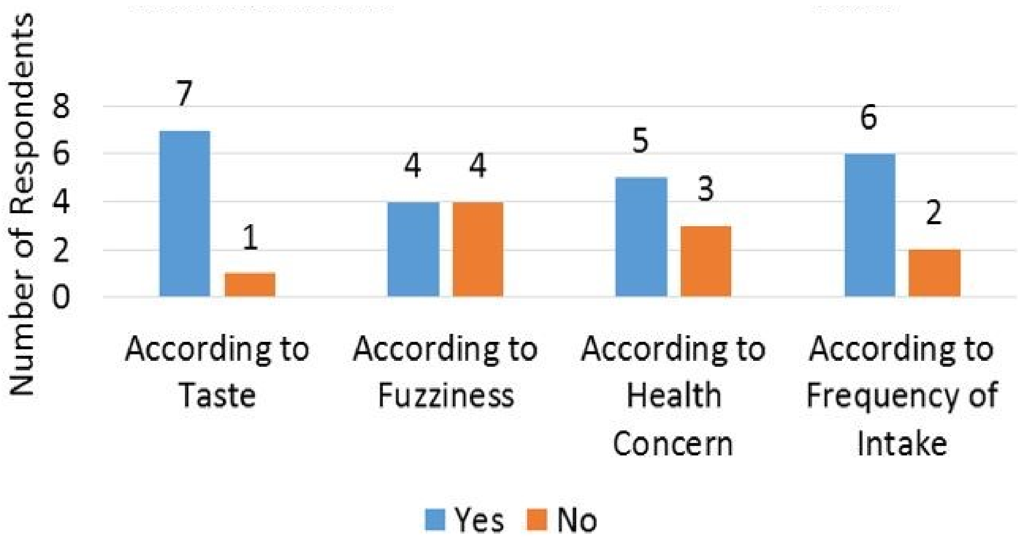


Table 5: Similarity of Food Choices in the Household (Non-South Non-Vegetarians)

Attributes (Placed Against Number of Respondents)	Similarity of Food Choices in the Household (Non-South Non-Vegetarians)											
	Dissimilar	Similar (Yes, My Choice Aligns with that of My Family)										
		Percentage of Similarity (%)										% of Similarity (Average)
		10	20	30	40	50	60	70	80	90	100	
Taste	8		11	5	4	4	3		3			38%
Fussiness	17		2	2	2	5	1	4	5			55%
Health Concern	7			4	2	5	4	3	6	5	2	65.40%
Frequency of Intake	7				2	6	2	4	4	5	8	75.80%

Table 6: Similarity of Food Choices in the Household (South Non-Vegetarians)

Attributes (Placed Against Number of Respondents)	Similarity of Food Choices in the Household (South Non-Vegetarians)											
	Dissimilar	Similar (Yes, My Choice Aligns with that of My Family)										
		Percentage of Similarity (%)										% of Similarity (Average)
		10	20	30	40	50	60	70	80	90	100	
Taste	8		11	3	6	3	2	4	3	1	1	45%
Fussiness	12	2	5	5	3	5	3	2	4		1	46%
Health Concern	10	2	8	4		6	4	1	5	2		46.50%
Frequency of Intake	13		3	1		5	3	2	7	7	1	67%

Table 7: Similarity of Food Choices in the Household (Non-South Vegetarians)

Attributes (Placed against Number of Respondents)	Similarity of Food Choices in the Household (Non-South Vegetarians)											
	Dissimilar	Similar (Yes, My Choice Aligns with that of My Family)										
		Percentage of Similarity (%)										% of Similarity (Average)
		10	20	30	40	50	60	70	80	90	100	
Taste	6		3			1	1				1	45%
Fussiness	7			1		1		1	2			62%
Health Concern				1		1	1		2	6	1	78.30%
Frequency of Intake	1					3	1		2	2	3	77.20%

Table 8: Similarity of Food Choices in the Household (South Vegetarians)

Attributes (Placed Against Number of Respondents)	Similarity of Food Choices in the Household (South Vegetarians)											
	Dissimilar	Similar (Yes, My Choice Aligns with that of My Family)										
		Percentage of Similarity (%)										% of Similarity (Average)
		10	20	30	40	50	60	70	80	90	100	
Taste	1		3					1	1	2		55.70%
Fussiness	4			1		1		2				55%
Health Concern	3			1	1			1	1	1		62%
Frequency of Intake	2			1					2	2	1	78.30%

example of a list of most commonly consumed Food Items in both categories was obtained as given in [Figure 15]. The results were plotted as Mean Food Item Frequency Scores [Tables 9-10].

Figure 15: Top 10 Commonly Scored Food Items in Food Frequency Chart (Non-South Population)

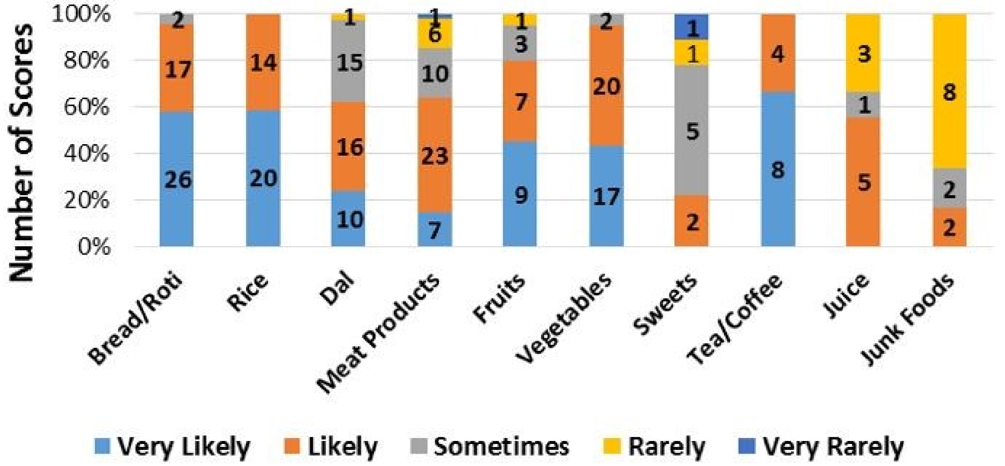


Table 9: Mean Food Item Frequency Score Non-South Population

Food Item	Very Likely	Likely	Sometimes	Rarely	Very Rarely	Mean (M)	Standard Deviation (Σ)
Bread/Roti	26	17	2			15	12.124356
Rice	20	14				17	4.2426407
Dal	10	16	15	1		10.5	6.8556546
Meat Products	7	23	10	6	1	9.4	8.2643814
Fruits	9	7	3	1		5	3.6514837
Vegetables	17	20	2			13	9.6436508
Sweets		2	5	1	1	2.25	1.8929694
Tea/Coffee	8	4				6	2.8284271
Juice		5	1	3		3	2
Junk Foods		2	2	8		4	3.4641016

Table 10: Mean Food Item Frequency Score South Population

Food Item	Very Likely	Likely	Sometimes	Rarely	Very Rarely	Mean (M)	Standard Deviation (Σ)
Idly/Dosa	20	14	1			11.666667	9.7125349
Rice	22	23	3			16	11.269428
Pongal	2	5	13	4	2	5.2	4.5497253
Meat Products	18	33	11	4	3	13.8	12.316655
Junk Foods	2	3	11	3	1	4	4.1932485
Vegetables	9	4	3			5.3333333	3.2145503
Bread	7	9	7	3		6.5	2.5166115
Poori	2	4	3			3	1
Juice	3	1	5			3	2
Tea/Coffee	13	6	4			7.6666667	4.7258156

An average of 13 respondents from the Non-South population indicated the weekly frequency of vegetable intake in contrast to only 5.3 South Indians (on average) cross-validates studies focusing on moderate to high heritability for the liking of vegetables in adults[24]. This heritability is seen a little more pronounced in Non-South than South, presumable as South Indians reportedly carry higher frequency of TAS2R38 bitter taste perception gene variant (homozygous dominant PAV/PAV or heterozygous dominant PAV/AVI) than Non-South, who carry more of homozygous non-taster (recessive AVI/AVI) allelic variant[55]. This is because people who perceive more bitterness report less liking of vegetables (PAV/PAV or AVI/AVI) and hence consume fewer vegetables[63], [65], [83].

Moderate heritability for sweets, high carbohydrate sources like rice or bread, and meat have been studied previously[84]. In agreement to previous literature, mean scores of respondents indicating weekly intake frequency for rice was 17 out of 50 respondents in Non-South and 16 out of 50 respondents in South; for Bread/Roti, it was 15 in Non-South and 6.5 in South; and for meat products, it was 9.4 in Non-South and 13.8 in South population. For tea/coffee, mean scores were 6 in Non-South and 7.6 in the South population. Further, lower weekly frequency of tea/coffee in the present sample population[65] is confirmed by studies on polymorphic variants of bitter-taste gene TAS2R43 that influences coffee liking[85], and PLCâ2 gene rare allelic variant rs2290550 reportedly linked to tea liking[65].

CONCLUSION

A comprehensive study on various aspects of food preferences, habits, and consequences for food-related diseases, like overweight/obesity, is of considerable public health importance to the food industry. This work promises improved dietary modification programs by identifying food frequency and multidimensional factors motivating food choices[86]. The list of factors affecting food preference, though not exhaustive, are interrelated in terms of context, and extrapolate contextual influences on food choices. Moreover, researchers face a challenge to understand the sum of all interactive effects of contextual factors influencing Eating Behavior[87] or account for each contextual influence throughout the day.

Gene regulation of dietary choices can be useful in personalized medicine, instruct nutritional education to youths of today, and impact the science of Nutrigenomics. Dietary education is necessary to understand the closely-knit genetic framework, counter obesity, and associated health risks. Hence, by understanding the etiology of our food choices, policymakers and dieticians can improvise on nutrition-related genetic abnormalities. Also, a societal shift towards a rational food choice can be achieved by analyzing other determinants, like vegetarian self-identity, plant-based diets, or a meat-free lifestyle that boasts environment sustainability and 'healthy' alternatives to meat-based protein sources. This can bring breakthroughs with reinforcing evidence that will be generated by genetic aspects on food choice. Food manufacturers and retailers can, in turn, promote the branding of sustainable alternatives under the aegis of extrinsic advantages of a less-meat diet. Government agencies can frame policies aimed at minimal exploitation of animals, disseminate knowledge on genetic implications and healthier alternatives to meat-based foods.

Any scientific study has to address the limitations it poses, and the present study has some of them as well. Firstly, the study compares food choice determinants between the South and Non-South Indian population, although gender-based differences which were reported previously, were not accounted for[88], [89]. Questionnaire data can sometimes show a discrepancy with actual Eating Behavior as intuitive thinking can usually take the upper hand in basic behaviors like determining food choices, and participants explicitly score responses without rational considerations[29]. Thinking and decision-making usually occur without conscious control[90], [29]. Also, situational contexts of food choices, which play a vital role in determining food choices, were not accounted for in this study. For example, hedonic hunger in the winter season would incite an urge to eat differently compared to a hot sunny day. In addition, this study does not have a well-balanced proportion of low-income groups, as more than half of the population declared above-average annual household income. This could explain why "Taste" was reported as the most significant factor in the population, as the sensory appeal of foods is more of a determinant for middle-to-high income groups than low-income groups[2]. Similarly, "Price Concern" was a relatively lower significant factor, and this can be attributed to more than 30% of respondents coming from a financially sound background.

There exists a lacuna in disentangling the complexities of food choices and contextual aspects of preferences. Hence, longitudinal data, experimental designs, and cross-sectional studies like this would address food choices in a broader sense of the Indian context. Also, the role of genetic influences on food selection needs no introduction, and there is more scope in identifying genes other than the ones involved in olfactory and taste perception, which can be determined by Heritability Analysis, Candidate Gene Studies, and Genome-Wide Association Studies (GWAS). Also, the present study sample, comprising only of students, can be extended to include more representative samples across various age groups.

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