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Perception of Nutrigenomics & Nutrigenetics among Albanian Young Adults

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Abstract According to World Health Organization, non-communicable diseases (NCDs) represent a significant health concern in Albania and account for 94% of the deaths of population in 2022. Hence, their prevention and control are one of the main goals of the Health System and Government Strategic Health Program in Albania. This study aims to explore the perspective of educated young adults on nutrigenomics and also to analyze some of the factors that will influence the decision making to undergo a genetic test for personalized nutrition or not. The data presented in this study were extracted from a cross-sectional survey that was conducted through a questionnaire. The participants in the study were undergraduate and graduate students at the Agricultural University of Tirana. Before submitting the questionnaire, the heads of the departments were informed, and permission was requested for the questionnaires to be distributed during the lecture hours in order to obtain a larger sample. Furthermore, before handing out the questionnaire, students were informed about the aim of the study and their right to decline participation. Questionnaires were codified with cardinal numbers and then grouped based on the students' major. A total of 848 students with different educational backgrounds completed the questionnaire from April to July 2019. Our findings suggest that there are statistically no sex-based differences between participants and the information they possess on nutrigenomics or personalized genetic tests (one way ANOVA, $F_{(1,845)} = 0.254$, $p=0.614$). However, we found a statistically significant difference in the means of the student's educational background and their perception toward nutrigenomics and personalized genetic tests. There is a significant difference in the means of the student's major and their perception that nutrigenomics science or personalized genetic tests are going to improve people's lifestyle ($F_{(7,840)} = 34.980$, $p<0.001$). The majority of the participants (46%) considered family history diseases as the main factor that will influence the decision to undertake a personalized genetic test. Studies that consider more inclusive samples and a wider range of factors are necessary in the near future for a smoother implementation of personalized genetic test in the public health sector in Albania.

Keywords Nutrigenomics, Nutrigenetics, Healthy Dietary, Non-communicable Diseases, Statistical Analyses

1. Introduction

Advances in nutrition and molecular techniques have led to a better understanding of the relationship between diseases and diet and between genome and diet [1]. For the last two decades, this relationship has been termed nutrition genetics, and it is a combination of two areas of research, nutrigenomics and nutrigenetics [2]. Nutrigenomics emphasizes the role of nutrients and bioactive compounds in gene expression [3]. On the other hand, nutrigenetics underlines the genetic difference between people (DNA fingerprinting, e.g., SNP) that will influence individual response to diet, leading to

personalized nutrition [4]. The Human Genome Project has estimated that a human has approximately 20,000 to 25,000 genes, and more than 10,000 human diseases are monogenic, thus, determined by one single gene (e.g., Huntington's Disease) [5], [6]. Besides the fact that genetic factors are the leading causes of chronic disease in humans, recent research suggests that environmental factor exposures and interaction between genes and these factors must also play a crucial role in acquiring a chronic disease [7]. Nutrition represents one of the leading environmental factors exposed to the human genome [8]. Therefore, molecular gene mechanisms, such as the regulation of gene expression, are highly dependent on nutrients and chemicals present in food [9], [10], resulting in a complex partnership between genes, diet, and disease. For these reasons, dietary interventions to prevent chronic disease require knowledge of how a single nutrient may affect a biological system and how a complex mixture (i.e., diet) of nutrients will interact to modulate bodily functions [11]. Nutritional science is beginning to better understand the interaction between genes and diet, with the potential to influence cardiovascular disease risk or another chronic disease by dietary modification [12-14]. Chronic diseases such as obesity, cardiovascular diseases, some types of cancer, diabetes also known as non-communicable diseases (NCDs), represent the primary concern in public health worldwide because they are the leading causes of global deaths, killing more people each year than all other causes combined [15]. The data from IHME (The Institute for Health Metrics and Evaluation at the University of Washington) in 2020 for Albania [16] shows the quite the same distributions patterns of NCD-s among Albanian population. According to the World Health Organization [17], the percentage of deaths from NCDs (heart disease, cancers, autoimmune diseases, others) in Albania is estimated to account for 94% of the total death occurrence in 2022. Despite the rapid growth and inequitable distribution, much of the human and social impact caused each year by NCDs related deaths could be averted through well-understood, cost-effective, and feasible interventions [15].

Based on these statistics, NCDs represent a significant concern for Public Health in Albania. There are some attempts in Albania to introduce genetic tests and the prescription of a personalized diet based on the genetic tests' results, but these attempts are random and mainly focused on diseases that are related to obesity, intolerance, or food allergy. It is essential for us to comprehend why personalized genetic tests are not being conducted in Albania. Is it a result of mistrust, misinformation, or other factors connected to beliefs or the unwillingness and unavailability to conduct genetic tests? The situation in Albania is different from other European countries, where these tests are taken more seriously and are well-regulated by law [18]. Most of the skepticism surrounding nutrigenomics can be attributed to the fact that it is still considered a multifaceted, not well-explored field of science [19]. It is a complex discipline that requires in-depth knowledge in the field of genetics, nutrition, biochemistry, or human physiology [20]. Furthermore, when discussing nutrigenomics and personalized genetic tests, it is inevitable not to include ethical issues such as the misuse of genetic information or invasion of privacy, and the feasibility related to the cost/availability of genetic tests for personalized nutrition. Due to these factors, the implementation of nutrigenomics science in the public health sector is quite challenging [21], [22]. Regardless of the aforementioned, scientists are confident that in addition to conventional treatment of NCDs, implementing personalized genetic tests will prevent or at least will reduce the onset and impact of non-communicable conditions that currently in Albania account for 94% of total deaths [17].

Based on this approach, our study analyzes data collected through a questionnaire, with the primary aim of evaluating the perception of Albanian well-educated young adults that either have graduated or are still majoring in nutrition, food technology, or food biotechnology, who are expected to be the future nutritionists and dieticians in Albania. Our secondary aim was to explore some of the factors that will influence the decision-making to undergo or not a genetic test for personalized nutrition. The output of this survey is not only to assess the students' perception toward nutrigenomics but also to highlight the shortcomings that need to be corrected and to shed light on some of the ethical issues related to personalized genetic tests that Albanian society needs to surpass.

2. Materials and Methods

This study is based on a cross-sectional survey conducted through the delivery of a questionnaire between April 2019 and July 2019. Participants in the questionnaire were students at the Agricultural University of Tirana aged between 18 to 25. Keeping in mind the controversial nature of nutrigenomics [23], we thought that the younger and more educated populations will be the optimal sample to evaluate the perception toward nutrigenomics. Furthermore, the selection of this target group was also based on other recent publications, which has focused on the perception of the population toward the nutrigenomics science and the impact of personalized genetic tests in the human lifestyle and society as a whole [24-26]. Students that participated in the survey were pursuing a degree in Veterinary Medicine, Food Science, Food Biotechnology, Food Technology, Agriculture and Environment, Horticulture, Aquaculture, or Business Information Technology during this time period, from April to July 2019. Before submitting the questionnaire, the heads of the departments were informed about the nature of the study, and permission was requested for the questionnaires to be distributed during the lecture hours in

order to obtain a larger sample. The participants were contacted personally and before handing out the questionnaire they were informed about the aim and content of the questionnaire and their right to decline participation in the survey. Questionnaires were codified with cardinal numbers and then grouped based on the students' major. After gathering all the delivered questionnaires, it resulted in a total sample of 848 undergraduate and graduate students that completed the questionnaire for the nutrigenomics & nutrigenetics survey.

2.1. Questionnaire Design for the Nutrigenomics & Nutrigenetics Survey

Questionnaire design for the survey was based on Julianne G. Wilkins research [26], for the perception of younger populations toward nutrigenomics, with some modifications that reflect the characteristics of the Albanian population. Furthermore, when designing the questionnaire for the survey towards nutrigenomics & nutrigenetics we took under consideration three main sectors in Albania: Education, Food, and Health Sciences. Basically, the questionnaire is composed of three parts. The first part contains questions regarding demographics characteristics, education status and the question: *If they have heard/or have information about nutrigenomics science or personalized genetic test.* The second part contains questions regarding the perception of the students toward nutrigenomics/nutrigenetics. A Likert scale was used to measure this perception, from strongly disagree (which has a numeric value equivalent to 1) to strongly agree (which has a numeric value equivalent to 5). The third part of the questionnaire contains questions regarding some of the factors that may affect the decision to undertake or not a genetic test for personalized nutrition.

2.2. Data Analyzes

All the data were analyzed with the statistical program SPSS 25.00. Crosstabulation, one way ANOVA, Pearson correlation, Tukey Post Hoc test (95% confidence level) and Paired t test were performed to examine the association between nutrigenomics/nutrigenetics and different variables. The independent variables are gender, the major the students attended during the survey, and the student's participation in genetics and nutrition classes. The dependent variables are the level of information and the perception of the students towards nutrigenomics and personalized genetic tests, and the factors that may influence the decision-making for taking a personalized genetic test in the future.

3. Results

3.1. Analyses of Demographic Data and General Characteristics of the Surveyed Population

Table 1 displays general characteristics of the surveyed population. The majors that students attended were categorized into eight groups. The majority of participants in the survey were undergraduate students (n=726) and 61.6% (n=522) were female. Undergraduate students attended majors in Veterinary medicine (n=148), Food technology (n=147), Food Science (n=101), Agriculture & Environment (n=101), Aquaculture (n=36), Horticulture (n=99) and Business IT (n=94). Graduated students were pursuing a master's degree in food biotechnology (n=122). Furthermore 88.7% (n=752) of students participating in the survey reported having taken genetics classes in college and 60.6% had attended nutrition classes.

Out of 522 female students, 10.8% had heard or had information about nutrigenomics science or personalized genetic tests (Question 7 of the questionnaire: *Have you ever heard or have information on nutrigenomics science or personalized genetics tests?*) as displayed in Table 2. On the other hand, 7.1% of the male students that attended different majors listed above did have information about the nutrigenomics science. The majority of the students (n=699) despite their gender or educational background have not heard about nutrigenomics science.

To understand if students' information toward nutrigenomic and personalized genetic differ between male and female or the information is depending on their education background, a one-way ANOVA and a Pearson (2-tailed) correlation coefficient were calculated. The data displayed in Table 3 show statistically no difference in the mean between male and female and the information they possess on nutrigenomics science or personalized genetic tests ($F_{(1,846)}=0.254$, $p=0.614$). There is a statistically significant correlation between genetics knowledge (students that have attended genetics classes in college) and the fact that they possess information on the nutrigenomics science and personalized genetic tests as displayed in Table 4 ($R^2=0.116$, $\alpha=99\%$, $p=0.001$).

Table 1. Demographic data and general characteristics of the surveyed population expressed as frequency and percentage.

Study profile	Sample	Gender		Nutrition class		Genetics class	
		Female	Male	Yes	No	yes	No
Veterinary medicine	n	85	63	144	4	146	2
	% of Total	10.00%	7.40%	17.00%	0.50%	17.20%	0.20%
Food technology	n	93	54	147	0	147	0
	% of Total	11.00%	6.40%	17.30%	0.00%	17.30%	0.00%
Food Biotechnology	n	79	43	122	0	122	0
	% of Total	9.30%	5.10%	14.40%	0.00%	14.40%	0.00%
Food Science	n	71	30	101	0	101	0
	% of Total	8.40%	3.50%	11.90%	0.00%	11.90%	0.00%
Agriculture & Environment	n	65	36	0	101	101	0
	% of Total	7.70%	4.20%	0.00%	11.90%	11.90%	0.00%
Aquaculture	n	25	11	0	36	36	0
	% of Total	2.90%	1.30%	0.00%	4.20%	4.20%	0.00%
Horticulture	n	74	25	0	99	99	0
	% of Total	8.70%	2.90%	0.00%	11.70%	11.70%	0.00%
Business IT	n	30	64	0	94	0	94
	% of Total	3.50%	7.50%	0.00%	11.10%	0.00%	11.10%
Total	n	522	326	514	334	752	334
	% of Total	61.60%	38.40%	60.60%	39.40%	88.70%	39.40%

Table 2. Male and female response on item express as frequency and percentage

			Gender		Total
			Female	Male	
Question7: Have you ever heard or have information on nutrigenomics science or personalized genetics tests?	Yes	n	89[a]	60[a]	149
		% within Question 7: Have you ever heard or have information on nutrigenomics science or personalized genetics tests	59.7%	40.3%	100.0%
		% of Total	10.5%	7.1%	17.6%
	No	n	433[a]	266[a]	699
		% within Question7: Have you ever heard or have information on nutrigenomics science or personalized genetics tests?	61.9%	38.1%	100.0%
		% of Total	51.1%	31.4%	82.4%
Total		n	522	326	848
		% within Question7: Have you ever heard or have information on nutrigenomics science or personalized genetics tests?	61.6%	38.4%	100.0%
		% of Total	61.6%	38.4%	100.0%

Notes: Each subscript letter denotes a subset of Gender categories whose column proportions do not differ significantly from each other at the .05 level

Table 3. Performing a one-way ANOVA to analyze the difference between the variables and student's gender

Variables	Gender	N	Mean	Std. Deviation	F	Sig.
Question 7: Have you ever heard or have information on nutrigenomics science or personalized genetics tests?	Female	522	11.8295	0.37643	0.254	0.614
	Male	326	11.816	0.38812		
	Total	848	11.8243	0.3808		
Personalized genetic tests are going to improve the people's lifestyle	Female	522	15.5441	1.4314	2.082	0.149
	Male	326	15.3988	1.41873		
	Total	848	15.4882	1.42746		
The results of the genetic test are going to produce discrimination among the population	Female	522	14.772	1.42898	3.114	0.078
	Male	326	14.6043	1.2025		
	Total	848	14.7075	1.34817		
Personalized genetic tests are going to be available for the entire population despite cost, gender, or ethnicity	Female	522	14.8161	1.0315	1.863	0.173
	Male	326	14.9172	1.0767		
	Total	848	14.855	1.04963		
Family disease history as a factor that will influence their decision to undertake a personalized genetic test	Female	522	15.2318	1.51192	2.913	0.088
	Male	326	15.0521	1.4572		
	Total	848	15.1627	1.49282		

Table 4. Pearson Correlation analysis between two variables: Genetics class and Information about nutrigenomics/personalized genetics tests.

		Question 5: Genetic Class	Question 7: Information about Nutrigenomics/Personalized Genetic Tests
Question 5: Genetic Class	Pearson Correlation	1	.116**
	Sig. (2-tailed)		.001
	N	848	848
Question 7: Information about Nutrigenomics/Personalized Genetic Tests	Pearson Correlation	.116**	1
	Sig. (2-tailed)	.001	
	N	848	848

**. Correlation is significant at the 0.01 level (2-tailed).

3.2. Analyses of Student Perception toward Nutrigenomics & Nutrigenetics

The second part of the questionnaire was focused on the perception that students have towards nutrigenomics science. Variables including statements such as: i) *Personalized genetic tests are going to improve the people's lifestyle*, ii) *The results of the genetic test are going to produce discrimination among the population*, iii) *Personalized genetic tests are going to be available for the entire population despite cost, gender, or ethnicity*, were analyzed. The data displayed in Annex Table 7 show that 59.9% (n=508) of the students choose to agree or strongly agree with the statement that personalized genetic tests are going to improve people's lifestyle. There is a clear difference between students majoring in Veterinary Medicine or Food Science and those majoring in Business IT or Horticulture when it comes to perception toward nutrigenomics & personalized genetic tests and their impact on improving population lifestyle. A total of 27.3% of the students majoring in Veterinary Medicine choose to strongly agree with the statement that personalized genetic tests are going to improve people's lifestyle compared with students majoring in Horticulture where only 4.2% of them choose to strongly agree. Furthermore, none of the students majoring in Business IT has chosen to strongly agree with the statement above. Discrimination related to nutrigenomics tests was one of the ethical issues analyzed in our survey, along with invasion of privacy or religious beliefs. The perception of the students towards these ethical issues in correlation with nutrigenomics tests was also related to the students' background/major that they attend. A total of 32.6% of the students majoring in Food Science choose to strongly disagree with the statement "*The results of the genetic test are going to produce discrimination among the population*," contrary to the students majoring in Horticulture where 44% of them choose to strongly agree with the statement above. It is imperative to emphasize that the majority of the students (n=440, 51.9%) perceive that genetic test for personalized nutrition will not result in discrimination, compared to 16% (n=136) of the students that were undecided and 32.1% of

the students that chose to agree/strongly agree (Likert scale) that genetic tests will indeed result in discrimination. Students chose to strongly disagree/disagree (n=347, 41%) for the statement "*Nutrigenomic testing would cost too much and would not be available for the entire population*", and 36% (n=293) of the students chose "neither agree nor disagree".

Table 5. Performing A One-Way ANOVA between students' major and perception toward nutrigenomics/nutrigenetics.

Variables	Students major	N	Mean	Std. Deviation	F	Sig
Personalized genetic tests are going to improve the people's lifestyle	Veterinary medicine	148	16.2365	1.00584	39.734	p<0.001
	Food technology	147	15.6327	1.25557		
	Food Biotechnology	122	16.1393	1.23526		
	Food Science	101	15.8317	1.34216		
	Agriculture and Environment	101	15.495	1.30095		
	Aquaculture	36	14.75	1.48083		
	Horticulture	99	14.5556	1.4654		
	Business IT	94	14.1277	1.01847		
	Total	848	15.4882	1.42746		
The results of the genetic test are going to produce discrimination among the population	Veterinary medicine	148	14.3446	0.93104	56.950	p<0.001
	Food technology	147	14.4966	1.08144		
	Food Biotechnology	122	14.2049	1.26582		
	Food Science	101	13.7624	1.18447		
	Agriculture and Environment	101	14.4554	1.30786		
	Aquaculture	36	15.3889	1.53582		
	Horticulture	99	16.2828	0.79591		
	Business IT	94	15.6277	1.01583		
	Total	848	14.7075	1.34817		
Personalized genetic tests are going to be available for the entire population despite cost, gender, or ethnicity.	Veterinary medicine	148	14.1554	0.90886	70.524	p<0.001
	Food technology	147	14.4354	0.54982		
	Food Biotechnology	122	14.4426	0.58985		
	Food Science	101	14.4158	0.57039		
	Agriculture and Environment	101	15.5248	1.22959		
	Aquaculture	36	15.75	1.0247		
	Horticulture	99	15.7071	0.83608		
	Business IT	94	15.6596	0.98977		
	Total	848	14.855	1.04963		
Family disease history as a factor that will influence their decision to undertake a personalized genetic test	Veterinary medicine	148	15.8986	1.3286	25.472	p<0.001
	Food technology	147	15.5918	1.18064		
	Food Biotechnology	122	15.4098	1.41278		
	Food Science	101	15.4653	1.36062		
	Agriculture and Environment	101	14.7624	1.62572		
	Aquaculture	36	14.4722	1.78063		
	Horticulture	99	14.6667	1.3924		
	Business IT	94	13.9043	1.04798		
	Total	848	15.1627	1.49282		

To understand if the perception toward the variables mentioned above depends on students' education background, a one-way ANOVA and a Tukey post hoc test were performed (95% confidence level). Our study shows that there is a statistically significant difference in the means of students' major and their perception towards the impact of nutrigenomics in society as displayed in Table 5. We found a statistically significant difference in the mean of the student's major and perception that nutrigenomics science or personalized genetic tests are going to improve people's lifestyle ($F_{(7,840)}$=39.734, p<0.001). Moreover, we found a statistically significant difference ($F_{(7,840)}$=56.950, p<0.001) in the mean of students' major and perception if the nutrigenomics science or personalized genetic tests are going to result in discrimination. Also, we found a statistically significant difference ($F_{(7,840)}$=70.524, p<0.001) in the mean of student's major and perception regarding nutrigenomics science or personalized genetic tests availability

Data displayed in Annex Table 8 are extracted from a Tukey Post Hoc test (95% confidence level) which enabled multiple comparisons within depending on variables: *i) Personalized genetic tests are going to improve the people's lifestyle, ii) The results of the genetic test are going to produce discrimination among the population, iii) Nutrigenomic testing would cost too much and would not be available for the whole population* and students study profiles that completed the questionnaire.

Furthermore, to understand if there is any difference between male and female participants in the questionnaire and their perception toward the variables mentioned above a one-way ANOVA was performed as shown in Table 3 and Figure 1. There are no statistically significant differences in the mean of male and female students' perception that nutrigenomics science or personalized genetic tests are going to improve people's lifestyle ($F_{(1,846)}$=2.812, p=0.094), as shown in Fig. 1A. In addition, we did not find any statistically significant differences in the mean of male and female students' perception that nutrigenomics science or personalized genetic tests are going to result in discrimination ($F_{(1,846)}$=3.114, p=0.078), as shown in Fig. 1B. Similarly, we did not find any statistically significant differences in the mean of male and female student's perception that nutrigenomics science or personalized genetic tests would cost too much and would not be available for the whole population ($F_{(1,846)}$=1.863, p=0.178) as shown in Fig. 1C.

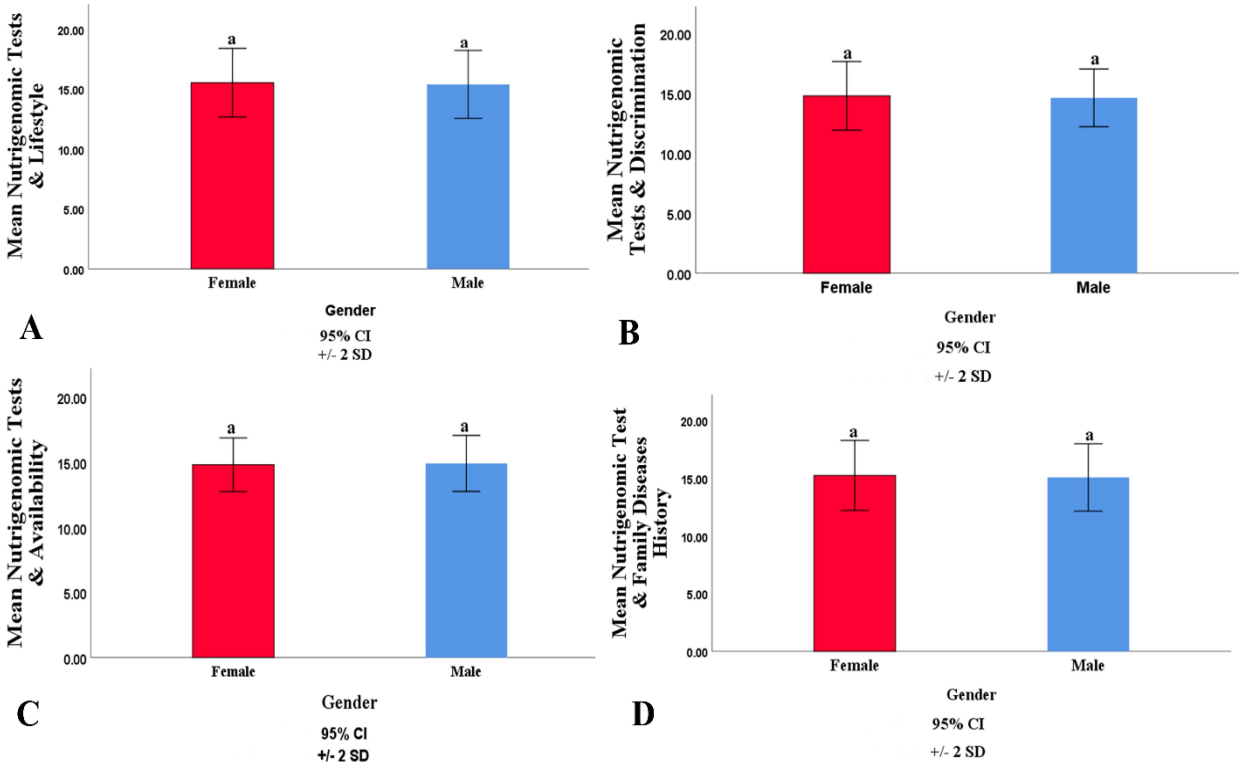

Figure 1: All the data in the graphs are extracted from statistical program SPSS 25.00. There is statistically no significant difference in the mean of students male and female perception toward variables: Part A) personalized genetic tests are going to improve the people's lifestyle, Part B) genetic test are going to produce discrimination among the population, Part C) personalized genetic tests are going to be available for the whole population despite cost, gender or ethnicity, Part D) family disease history as a factor that will impact their decision to undertake genetic tests.

3.3. Analyses of Factors to Consider Personalized Genetic Tests

Table 6. Paired t test analyzes

		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	Nutrition Course - Family Disease History as a factor for taking personalized genetic test	-3.76887	1.73603	0.05962	-3.88588	-3.65186	-63.219	847	<0.001
Pair 2	Genetics Course - Family Disease History as a factor for taking personalized genetic test	-4.04953	1.61747	0.05554	-4.15855	-3.94051	-72.907	847	<0.001

Paired difference:95% confidence interval of the difference

As noted above, the third part of the questionnaire took into consideration some factors that influence the decision-making whether or not to undergo a nutrition test for personalized nutrition. Family history of disease was one of the main factors that contributed to the decision to undergo a genetic test or not besides cost, anxiety regarding the test results, personal beliefs etc. 46% (n=391) of the students chose to answer "very likely/ completely likely" that family history of diseases will push them to undergo a nutrigenomics test as shown in the Annex Table 7. The data show statistically no difference in mean between male and female students' perception toward family disease history as a factor that will influence their decision to undertake a personalized genetic test as shown in Table 3 ($F_{(1,846)}$=2.913, p=0.088), and Fig. 1D.

We found a statistically significant difference in the mean between students' major and family history of disease as a factor that will influence their decision to undergo a personalized genetic test as displayed in Table 5 ($F_{(7,840)}$=25.472, p<0.001). A paired t-test was conducted to analyze two pairs of variables as displayed in Table 6. Pair 1: Students that have attended nutrition classes in university and their perception toward family history of disease as a factor that will impact their decision to undertake a genetic test. The difference in means is statistically significant, t(847)=-63.219, p<0.001. Pair 2: Students that have attended genetic classes in university and their perception toward family history of disease as a factor that will impact their decision to undertake a genetic test. The difference in means is statistically significant, t(847)=-72.907, p<0.001. Students that had attended genetics and nutrition classes in university were more likely to undertake a genetic test for personalized nutrition, especially when they have a family history of disease. Once again, the importance of genetic and nutrition classes was emphasized, as a tool for a better understanding of the nutrigenomics science or genetics tests for personalized nutrition.

4. Discussion

This study represents the first attempt to assess the Albanian young adults' perception toward nutrigenomics and nutrigenetics. Due to the complex nature of the nutrigenomics science, a target group which is well educated, and most of them are assumed to be the future dieticians, nutritionists, or geneticists in Albania, were submitted to the questionnaire. Our data show that the majority of the participants (n=699) despite their gender or educational background have not heard about nutrigenomics science. Only 17.6% (n=149) of the participants have heard or have information on nutrigenomic personalized genetic tests. We found a statistically significant correlation (R^2=0.116, α=99%, p=0.001) between genetics knowledge (students that have attended genetics classes in college) and the fact that they possess information on the nutrigenomics science and personalized genetic tests. Various studies in this field have shown that even among dietitians and nutritionists the level of knowledge toward nutrigenomics is low [27-28]. A study [29] on perception of Canadian health care professionals (dieticians, nutritionists, and physicians), indicates that they have little knowledge about nutritional genomics, regardless of their educational background. These results necessitate the attention of the academician and the curriculum developers to plan interventional strategies and health-care professionals need to take steps to prepare for nutrigenomics arrival and implementation.

The second part of the study was focused on the perception that students have towards nutrigenomics science and its impact in improving people's lifestyle, producing discrimination or the availability of genetic test for the entire population. To our best knowledge, there is a discrepancy in approaches among scientists in terms of nutrigenomics and personalized genetic tests. According to some publications, potential advantages of personalized

genetic testing include relief from anxiety, improved ability to plan for the future, and more informed decisions regarding measures that may or may not play a role in disease prevention or treatment [30]. On the other hand, there are scientists who emphasize potential risks and disadvantages from personalized genetics tests, such as cost of testing, psychological and emotional reactions to results, disruption to families, and potential for discrimination [31]. According to our results, 59.9% of the students (n=508) consider nutrigenomics and nutrigenetics a tool that is going to improve people's lifestyle and 51.9% (n=440) perceive that genetic test for personalized nutrition is not a potential for discrimination. Our findings are comparable to those of similar surveys conducted in other European countries where most of the respondents (66 %) reported that they would be willing to undergo genetic testing, and the majority of them were more likely to report a history on NCDs (high blood cholesterol levels, obesity, others) [32]. In our study, 46% (n=391) of the participants in the survey chose to answer "very likely/ completely likely" that family history of disease will push them to undergo a nutrigenomics test. As regards the availability of personalized genetics tests for the entire population, approximately 36% of the students were undecided. We believe that the economic inequality prior to and after 1990 in Albania encourages this unclear perception among students that have chosen "neither agree nor disagree" for the above statement. Moreover, this perception of the Albanian population is in accordance with a recent survey of a sample of the European population, where 30% of respondents are certain that individualized genetic counseling would be useful in correcting their eating habits but believe that paying for such a service is inappropriate [33]. Furthermore, when presenting an innovative technology to the consumer, a key determining factor for the acceptance is the cost/benefits binomial [34]. In addition, as suggested from findings of other surveys, there is a low willingness of the consumers to pay out-of-pocket for testing [35]. Not all our findings back up those of previous studies. According to our results, the perception toward all the variables that we took under consideration is not gender dependent. We found no significant differences in mean between male and female perceptions toward nutrigenomics or variables that will influence their decision to undergo a genetic test for personalized nutrition. Meanwhile, quantitative research conducted in European countries indicate that male have a skeptic perception toward nutrigenomic tests and are less likely to have a personalized genetic test [32]. Another quantitative survey in Hungarian consumers found that females are significantly less likely to reject the innovative technology compared to male [36]. It is important to underline that our study shows a statistically significant difference in the mean of the student's major and perception that nutrigenomics science or personalized genetic tests are going to improve people's lifestyle ($F_{(7,840)}$=39.734, $p<0.001$). Moreover, we found a statistically significant difference ($F_{(7,840)}$=56.950, $p<0.001$) in the mean of students' major and perception if the nutrigenomics science or personalized genetic tests are going to result in discrimination. Also, we found a statistically significant difference ($F_{(7,840)}$=70.524, $p<0.001$) in the mean of students' major and perception regarding nutrigenomics science or personalized genetic tests availability. Various studies demonstrated the importance of the education background in genetics, genomics, and epigenetics in nutrition toward the perception and implementation of nutrigenomic science [37-38].

The participants' approach towards nutrigenomics tests for personalized nutrition is in line with the vision and objectives of the National Program on Prevention and Control of NCDs 2016-2020 [39]. What is even more encouraging is that the students, regardless of their gender, demonstrated a positive attitude toward nutrigenomic science and personalized genetic tests. However, we believe that the future implementation of nutrigenomics and nutrigenetics in the health system in Albania would be quite a challenge. We are aware that many steps need to be taken, especially in the Education and Health sector in Albania, in order to understand the benefits of nutrigenomics science, to accept it, and then to be able to implement it. This study pointed out the significance of having knowledge in several fields of science, i.e., genetics and nutrition, in order to have a positive attitude toward nutrigenomics or individualized genetic tests. The first step to achieve this task is by improving the curricula in HEIs in line with new scientific findings, which is not only an Albanian challenge for the Education and Health Sector, but also a global challenge, underlined in various publications [40]. Introducing this feasible intervention will pave the way for the establishment of well-prepared nutritionists and dietitians in the Albanian health sector.

4.1. Limitations

This study was conducted only among students at Agricultural University of Tirana and a limited number of variables were taken into consideration to assess the youth's perception toward nutrigenomics and to underline the factors that will influence their decision to undertake a personalized genetic test. Further studies that consider a larger and more inclusive sample and a wider range of factors are necessary in the near future. To our best knowledge, this is the first time that a questionnaire of this nature is conducted in Albania generating a literature gap which makes it difficult to compare the data.

5. Conclusions

This survey highlighted the shortcomings and the need for improvement, especially in the education sector, towards this novel science which is updated periodically

with the latest information related to genetics and nutrition. The questionnaire used for this survey enabled a multidimensional analysis that included three main pair variables: i) nutrigenomics/personalized genetic test as a novel science, ii) nutrigenomics/ personalized genetic test and human population lifestyle, iii) nutrigenomics/ personalized genetic test versus society ethics.

Based on our findings, students that have attended genetics or nutrition classes have a better perception toward nutrigenomics science, in comparison to the students that have a different scientific background. Furthermore, students perceive nutrigenomics science or personalized genetic tests as tools that are going to improve people's lifestyle and are not going to lead to discrimination among users. In both cases, students' information and perception toward this controversial science were not related to their gender.

We think that a scarcity in credible nutrigenomic education opportunities is the main factor for health professionals' skepticism in Albania and for not taking steps towards growth, translation, and utilization of nutrigenetic tests. This conclusion aligns with existing literature. The first step for filling this gap is updating the curricula in Higher Education Institutions. This is an ongoing study, and further work needs to be done in this unexplored sector in Albania, but we obviously consider these preliminary results as the foundations on which other studies will continue.

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Conflict of Interest

Non to Declare

Appendix

Annex Tables

Table 7. Students perception toward nutrigenomics/nutrigenetics based on their educational background. Data expressed as frequency and percentage

Study Profile		Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Total
Veterinary medicine	Count	6	6	7	57	72	148
	% within Personalized genetic tests are going to improve the people's lifestyle	4.40%	6.80%	6.00%	23.40%	27.30%	17.50%
Food technology	Count	12	20	20	53	42	147
	% within Personalized genetic tests are going to improve the people's lifestyle	8.90%	22.70%	17.10%	21.70%	15.90%	17.30%
Food Biotechnology	Count	11	5	4	38	64	122
	% within Personalized genetic tests are going to improve the people's lifestyle	8.10%	5.70%	3.40%	15.60%	24.20%	14.40%
Food Science	Count	13	3	13	31	41	101
	% within Personalized genetic tests are going to improve the people's lifestyle	9.60%	3.40%	11.10%	12.70%	15.50%	11.90%
Agriculture and Environment	Count	11	11	24	27	28	101
	% within Personalized genetic tests are going to improve the people's lifestyle	8.10%	12.50%	20.50%	11.10%	10.60%	11.90%
Aquaculture	Count	10	8	5	7	6	36
	% within Personalized genetic tests are going to improve the people's lifestyle	7.40%	9.10%	4.30%	2.90%	2.30%	4.20%
Horticulture	Count	36	18	10	24	11	99
	% within Personalized genetic tests are going to improve the people's lifestyle	26.70%	20.50%	8.50%	9.80%	4.20%	11.70%
Business IT	Count	36	17	34	7	0	94
	% within Personalized genetic tests are going to improve the people's lifestyle	26.70%	19.30%	29.10%	2.90%	0.00%	11.10%
Total	**Count**	**135**	**88**	**117**	**244**	**264**	**848**
	% within Personalized genetic tests are going to improve the people's lifestyle	**15.91%**	**10.40%**	**13.79%**	**28.77%**	**31.13%**	**100.00%**
Veterinary medicine	Count	18	87	20	20	3	148
	% within Genetic test are going to produce discrimination among the population	9.50%	34.80%	14.70%	12.30%	2.70%	17.50%
Food technology	Count	12	92	14	16	13	147
	% within Genetic test are going to produce discrimination among the population	6.30%	36.80%	10.30%	9.90%	11.80%	17.30%
Food Biotechnology	Count	50	28	19	19	6	122
	% within Genetic test are going to produce discrimination among the population	26.30%	11.20%	14.00%	11.70%	5.50%	14.40%

Table 7 continued

Food Science	Count	62	20	4	11	4	101
	% within Genetic test are going to produce discrimination among the population	32.60%	8.00%	2.90%	6.80%	3.60%	11.90%
Agriculture and Environment	Count	34	16	32	9	10	101
	% within Genetic test are going to produce discrimination among the population	17.90%	6.40%	23.50%	5.60%	9.10%	11.90%
Aquaculture	Count	8	0	11	4	13	36
	% within Genetic test are going to produce discrimination among the population	4.20%	0.00%	8.10%	2.50%	11.80%	4.20%
Horticulture	Count	0	0	21	29	49	99
	% within Genetic test are going to produce discrimination among the population	0.00%	0.00%	15.40%	17.90%	44.50%	11.70%
Business IT	Count	6	7	15	54	12	94
	% within Genetic test are going to produce discrimination among the population	3.20%	2.80%	11.00%	33.30%	10.90%	11.10%
Total	**Count**	**190**	**250**	**136**	**162**	**110**	**848**
	% within Genetic test are going to produce discrimination among the population	**22.41%**	**29.48%**	**16.04%**	**19.10%**	**12.97%**	**100.00%**
Veterinary medicine	Count	33	77	20	18	0	148
	% within Nutrigenomic testing would cost too much and would not be available for the entire population	61.10%	26.30%	6.60%	15.80%	0.00%	17.50%
Food technology	Count	4	75	68	0	0	147
	% within Nutrigenomic testing would cost too much and would not be available for the entire population	7.40%	25.60%	22.30%	0.00%	0.00%	17.30%
Food Biotechnology	Count	6	56	60	0	0	122
	% within Nutrigenomic testing would cost too much and would not be available for the entire population	11.10%	19.10%	19.70%	0.00%	0.00%	14.40%
Food Science	Count	4	51	46	0	0	101
	% within Nutrigenomic testing would cost too much and would not be available for the entire population	7.40%	17.40%	15.10%	0.00%	0.00%	11.90%
Agriculture and Environment	Count	3	22	27	17	32	101
	% within Nutrigenomic testing would cost too much and would not be available for the entire population	5.60%	7.50%	8.90%	14.90%	39.00%	11.90%
Aquaculture	Count	0	6	6	15	9	36
	% within Nutrigenomic testing would cost too much and would not be available for the entire population	0.00%	2.00%	2.00%	13.20%	11.00%	4.20%

Table 7 continued

Horticulture	Count	0	0	53	22	24	99
	% within Nutrigenomic testing would cost too much and would not be available for the entire population	0.00%	0.00%	17.40%	19.30%	29.30%	11.70%
Business IT	Count	4	6	25	42	17	94
	% within Nutrigenomic testing would cost too much and would not be available for the entire population	7.40%	2.00%	8.20%	36.80%	20.70%	11.10%
Total	**Count**	**54**	**293**	**305**	**114**	**82**	**848**
	% within Nutrigenomic testing would cost too much and would not be available for the entire population	**6.37%**	**34.56%**	**35.97%**	**13.44%**	**9.66%**	**100.00%**
		Not at all	Likely	Neutral	Very Likely	Completely Likely	Total
Veterinary medicine	Count	14	14	12	41	67	148
	% within Family History Disease	8.28%	9.52%	8.51%	25.78%	28.87%	17.48%
Food technology	Count	3	30	36	33	45	147
	% within Family History Disease	1.77%	20.40%	25.53%	20.75%	19.39%	17.33%
Food Biotechnology	Count	15	20	28	18	41	122
	% within Family History Disease	8.87%	13.60%	19.85%	11.32%	17.67%	14.38%
Food Science	Count	12	13	23	22	31	101
	% within Family History Disease	7.10%	8.84%	16.31%	13.83%	13.36%	11.91%
Agriculture and Environment	Count	34	20	8	14	25	101
	% within Family History Disease	20.11%	13.60%	5.67%	8.80%	10.77%	11.91%
Aquaculture	Count	19	3	2	2	10	36
	% within Family History Disease	11.24%	2.04%	1.41%	1.25%	4.31%	4.24%
Horticulture	Count	28	21	18	20	12	99
	% within Family History Disease	16.56%	14.28%	12.76%	12.57%	5.17%	11.67%
Business IT	Count	44	26	14	9	1	94
	% within Family History Disease	26.03%	17.68%	9.92%	5.66%	0.43%	11.08%
Total	**Count**	**169**	**147**	**141**	**159**	**232**	**848**
	% within Family History Disease	**19.90%**	**17.30%**	**16.60%**	**18.80%**	**27.40%**	**100.00%**

Table 8. Tukey Post Hoc test (95% confidence level) analyzes. Statistical significance differences between students' major and dependent variables

Dependent Variable	(I) Study Profile	n	(J) Study Profile	Mean Difference (I-J)	Std. Error	Sig.
Nutrigenomic Tests & Lifestyle	Veterinary medicine	148	Food technology	.60383*	0.14467	0.001
			Agriculture and Environment	.74144*	0.16035	<0.001
			Aquaculture	1.48649*	0.23088	
			Horticulture	1.68093*	0.16131	
			Business IT	2.10883*	0.16386	
	Food technology	147	Aquaculture	.88265*	0.23103	0.004
			Horticulture	1.07710*	0.16153	<0.001
			Business IT	1.50499*	0.16408	
	Food Biotechnology	122	Agriculture and Environment	.64429*	0.16714	0.003
			Aquaculture	1.38934*	0.23564	<0.001
			Horticulture	1.58379*	0.16806	
			Business IT	2.01168*	0.17051	

Table 8 continued

	Food Science	101	Aquaculture	1.08168*	0.24116	
			Horticulture	1.27613*	0.17571	
			Business IT	1.70402*	0.17805	
	Agriculture and Environment	101	Aquaculture	.74505*	0.24116	0.043
			Horticulture	.93949*	0.17571	<0.001
			Business IT	1.36739*	0.17805	
Nutrigenomic Tests & Discrimination	Veterinary medicine	148	Food Science	.58222*	0.14389	0.001
			Aquaculture	-1.04429*	0.20718	<0.001
			Horticulture	-1.93823*	0.14475	
			Business IT	-1.28306*	0.14704	
	Food technology	147	Food Science	.73422*	0.14408	
			Aquaculture	-.89229*	0.20731	
			Horticulture	-1.78623*	0.14494	
			Business IT	-1.13106*	0.14723	
	Food Biotechnology	122	Aquaculture	-1.18397*	0.21145	
			Horticulture	-2.07791*	0.1508	
			Business IT	-1.42274*	0.153	
	Food Science	101	Agriculture and Environment	-.69307*	0.15688	
			Aquaculture	-1.62651*	0.2164	
			Horticulture	-2.52045*	0.15767	
			Business IT	-1.86528*	0.15977	
	Agriculture & Environment	101	Aquaculture	-.93344*	0.2164	
			Horticulture	-1.82738*	0.15767	
			Business IT	-1.17221*	0.15977	
	Aquaculture	36	Veterinary medicine	1.04429*	0.20718	
			Horticulture	-.89394*	0.21697	0.001
	Horticulture	99	Business IT	.65517*	0.16055	0.001
Nutrigenomic Test & Available	Agriculture and Environment	101	Veterinary medicine	1.36935*	0.10796	<0.001
			Food technology	1.08938*	0.10811	
			Food Biotechnology	1.08213*	0.11253	
			Food Science	1.10891*	0.11771	
	Aquaculture	36	Veterinary medicine	1.59459*	0.15545	
			Food technology	1.31463*	0.15555	
			Food Biotechnology	1.30738*	0.15865	
			Food Science	1.33416*	0.16237	
	Horticulture	99	Veterinary medicine	1.55167*	0.10861	
			Food technology	1.27170*	0.10875	
			Food Biotechnology	1.26445*	0.11315	
			Food Science	1.29123*	0.1183	
	Business IT	94	Veterinary medicine	1.50417*	0.11032	
			Food technology	1.22420*	0.11047	
			Food Biotechnology	1.21695*	0.1148	
			Food Science	1.24373*	0.11988	

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