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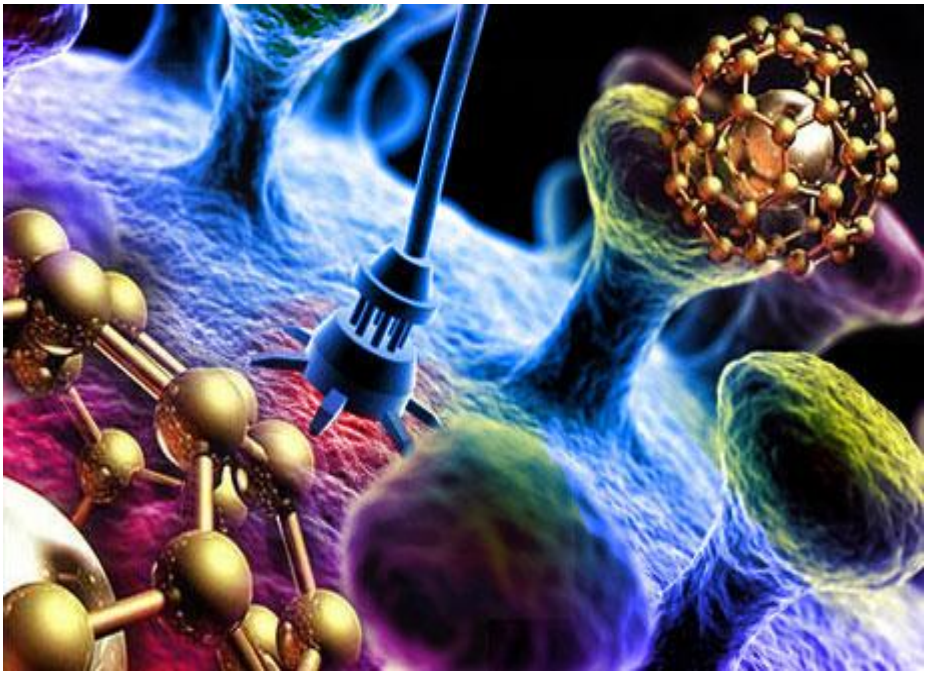
A STUDY OF AWARNESS AND PERCEPTION OF NANOTECHNOLOGY IN A UNIVERSITY SAMPLE POPULATION



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ABSTRACT

Nanotechnology is an emerging technology used to manipulate and produce nano-sized structures which are used for a variety of applications including in the food industry. A survey was conducted on 145 university students on the St. Augustine campus in Trinidad. Participants were given general information on nanotechnology and its risks and benefits. Most of the population was aware of nanotechnology and results found that majority of the sample perceived risks as overweighing benefits. Overall, the intent to purchase nanotechnology foods were low and was linked to negative perceived risks and low trust in food laws and food manufacturers. The need for more information was apparent for respondents to make choice as to whether nanotechnology would have a positive or negative effect on the food industry if implemented in Trinidad.

1.0 INTRODUCTION

Nanotechnology can be defined as a modern technology used to manipulate and produce structures and materials at the nano (10^{-9}) size (Asadi and Mousavi, 2006; Bass, 2008) These microscopic structures (called nano-particles or nano-materials) have a variety of applications to various fields such as in medicine, chemical catalysis and filtration techniques, energy reduction and energy efficiency, information technology, heavy industry (such as for making aircraft and vehicle materials), consumer goods such as cosmetics, and food and agriculture.

"The first documented introduction to nanotechnology took place in 1959, when Nobel Prize-winning physicist Richard Feynman gave a talk entitled "There's Plenty of Room at the Bottom". Although not actually using the term nanotechnology at the time, his talk portended its future research by raising the issue of building tiny machines with the ability of manufacturing objects with atomic exactitude, in essence a "bottom up" approach to manufacturing. He also suggested that data could be stored with tremendous density." (iscid.org)

"The word "nanotechnology" was first used in 1974 by Prof. Norio Taniguchi of Tokyo Science University to describe precision micromachining. However, discussions related to the topic did not really begin until 1986, when engineer K. Eric Drexler published his seminal work entitled *Engines of Creation: The Coming Era of Nanotechnology* in which he unwittingly usurped the term and became known as its creator." (iscid.org)

Creating nano-sized particles and applying them to foods and food packaging materials allows for a variety of desired properties to the food product. Nano-particles applied to packaging materials can create materials termed as 'smart' packaging which are more light resistant,

mechanically stronger, more heat resistant and less permeable to gas(Asadi and Mousavi, 2006). In turn, these properties cause the shelf life to increase as well as enhance flavor and colour. 'Smart' packaging material also "can respond to environmental conditions or repair itself or alert a consumer to contamination and/or the presence of pathogens" (Asadi and Mousavi, 2006).

Along with desirable enhancement of flavor, nanotechnology allows for the production of nano-sensors, which when embedded into foods, can warn the consumer when a food goes rotten (Asadi and Mousavi, 2006).

Although the benefits of nanotechnology have been recognized, researchers have found many associated risks with the emerging technology. The controversy surrounding the use of nano-particles is prevalent. These tiny particles are eighty thousand times smaller than the width of a strand of human hair and are able to penetrate the body, crossing the blood-brain barrier which is intended to protect the brain from harmful toxins (Bass, 2008). "The toxicological nature of hazard, exposure and risks to consumers from nanotechnology-derived food/food packaging are largely unknown…" (Chaudry et al, 2008).

With the wide range of consumer goods and packaging that are anticipated to be produced and marketed using nanotechnology, one of the potential risks to be investigated is possible nano-toxicity (Chaudry et al, 2008; Bass, 2008). Regulations on the amounts of nano-particles used in the production process are still under discussion by the Food and Drug Administration. Exposure of nano-particles to workers during the food production process can also be a means by which nano-toxicity can occur. As such, protocol for the management and prevention of nano-toxicity is still under discussion to avoid the possible serious complications to health.

“ The application of nanotechnology in food has, therefore, led to concerns that ingestion of nano-sized ingredients and additives through food and drinks may pose certain hazards to consumer health. Such concerns have arisen from a growing body of scientific evidence which indicates that free engineered nano-particles can cross cellular barriers and that exposure to some forms can lead to increased production of oxy-radicals and, consequently, oxidative damage to the cell.” (Chaudry et al, 2008).

The intestinal wall allows for the passage of dietary nutrients which are comparable in size to nano-ingredients that are added to many processed foods. The concern is that even though these nano-ingredients are different in chemical structure than the naturally occurring ingredients, they are still able to be absorbed readily. Greater absorption of nano-ingredients may lead to a change in a person’s nutrient profile and/or health consequences. (Chaudry et al, 2008).

There has also been discussion about the relationship between the strong antimicrobial activity of nano-particles and its effect on intestinal flora. However, there is no published research on this area of investigation (Chaudry et al, 2008).

1.1 RATIONALE

The study seeks to determine student awareness of nanotechnology and investigate underlying relationships between consumer nutrition knowledge, trust in the governmental food laws and intent to purchase nanotechnology-derived foods.

How individuals respond to and perceive nanotechnology and its risks and benefits may be as a result of the culture and economic situation of the country. At a psychological stand point, a person's emotional and affective responses drive the attitude towards a concept. Emotions, values and cultural beliefs may play an essential part in the perception process of nanotechnology (Norman, 2003).

Studies conducted on nanotechnology and public perception in the Caribbean were not found during research. However, those published in other regions such as the US, Switzerland and the UK were found and used as comparative studies to this one.

Research conducted on nanotechnology in Trinidad will seek to spread awareness of the technology and its various applications in several sectors (if it is low) and further educate the public about nanotechnology applications. Public awareness of nanotechnology is indefinite in Trinidad and the Caribbean and may be due to the fact that it is not implemented in food companies of the region.

It is not certain if local Caribbean food companies utilize nanotechnology in food production or packaging. Application of this technology may be a financial burden and overly time consuming for the companies' budget. There is also little information known about the benefits and potential harmful effects nano-particles can have on the body.

1.2 PROBLEM STATEMENT

Nanotechnology awareness and perception of the public are comprised in the key findings of this study. Low or high awareness of nanotechnology may present to the government, food manufacturers' and the scientific community an outlet to increase public confidence in nanotechnology foods. Also, in not making the public familiar with the emerging technology, it may be framed by misimpressions and misinformation. (Hart, 2008) Low public trust in government and regulatory agencies also may have an effect on the perception and willingness to purchase nano-products. Past safety issues with products, ranging from drugs to genetically engineered crops, have led to widespread perception that industry pushes products to the market without adequate safety testing, affecting people's health and putting their motives ahead of consumer safety. (Macoubrie, 2005)

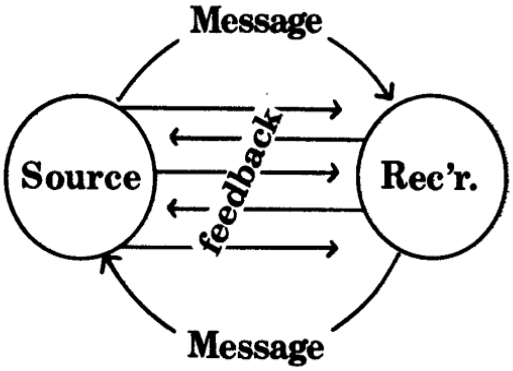
The purpose of this study is to investigate student awareness and consumers' willingness to purchase foods that are produced using nanotechnology. Consumers should be aware of the risks and benefits associated with the technology and should be able to make informed nutrition decisions.

1.3 SCOPE

The study will be conducted on university students attending University of the West Indies, St. Augustine in Trinidad. The sample size will contain 145 participants who will partake in a survey which will educate the subject about nanotechnology and determine awareness, perception and attitudes.

1.4 THEORETICAL FRAMEWORK

A communicator's role is to get information to people, ideally through the most effective and efficient channels (Calvert, 2000). Information may be transmitted through various channels to the receiver, however this pose a danger in sending information that may leave the receiver confused and with the wrong perception of the message. The communication process is likely to fail due to: failure to share meaning of words such as jargon words; failure of the communication channel for example, radio to transmit information over television; lack of attention to or lack of interest in the message.(Calvert, 2000)There are many obstacles in the way of reaching audiences with information. Below is a diagram of the communication process.

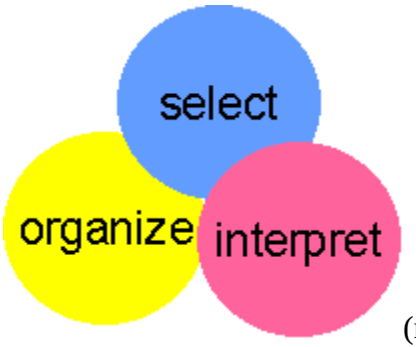


(www.ovc.edu)

Communication of scientific information and emerging technologies can be extra difficult due to its relative lack of familiarity by the public. Any information that may negatively portray a new science may result in negative outlook and public perception.

Feedback is an important aspect of knowing how the receiver perceives the message. Perception is a three phase process of selecting, organizing and interpreting information. An individual may select the information that is most relevant and most astounding to them. They then organize this

information into an understandable form, thereby finding out its real meaning. The interpretation step is where the individual may make decisions about the information gathered, by either forming a positive or negative perception of the message. Cognition plays an important role here in interpreting the world of information, leading to more understanding and knowledge.



(novaonline.nvcc.edu)

An individual's *affective and emotional responses* affect their attitudes towards nanotechnology (Kahan et al, 2007). Emotion deals with a person's mood, temperament, personality and disposition. The affective response deals with the consequences of a person's emotional state (Norman, 2003). A person's experiences affect their emotions and thus their attitudes and behaviors.

There are three different levels of how the brain processes information: visceral, behavioral and reflective. The visceral level makes rapid judgments of what is good or bad, safe or dangerous and sends signals to the muscles and the rest of the brain. The behavioral level deals with the behaviors and actions carried out by the individual. The affective response begins at this stage since behaviors is a consequence of the judgments made in the visceral level. The reflective level deals with reflective thought. Here the individual may 'second guess' the decisions made and actions done (Norman, 2003).

1.5 GENERAL OBJECTIVE TO:

-Evaluate student awareness and perception of nanotechnology.

1.6SEPCIFIC OBJECTIVES TO:

1. Investigate the sample populations' awareness of nanotechnology and its applications in the food industry and other fields.

2. Examine the awareness and perception of the risks and benefits of nanotechnology.

3. Determine the students' consumer intent to purchase and consume nanotechnology foods.

4. Report the sample populations' perception of implementing nanotechnology to the food industry in Trinidad.

5. Illustrate the intent to purchase and consume nanotechnology foods in individuals based on their comprehension of the nutrition facts panel and based on importance of taste and safety when buying foods.

1.7HYPOTHESES:

1. Those respondents who have no belief in food laws and food manufacturers will show less intent to purchase and consume nanotechnology foods. This hypothesis was formulated based on results found from a study conducted by Michael Siegrist et al in 2007 where it was observed that persons with no trust in government and food agencies showed less willingness to buy nanotechnology foods.

2. Those respondents who perceive that nanotechnology risks overweigh benefits will show less intent to purchase and consume nanotechnology foods. This hypothesis was also formulated based on results found in the study conducted by Michael Siegrist et al, 2007 where it was found that persons who perceived risks as overweighing benefits showed less willingness to buy nanotechnology foods.

3. Males are more likely than females to think that nanotechnology risks overweigh the benefits. This hypothesis was formulated based on results found in the study conducted by Kahan et al in 2007. The results revealed that significantly more males than females think that risks outweigh benefits.

2.0 LITERATURE REVIEW

2.1 NANOTECHNOLOGY AND THE GLOBAL MARKET.

The definition of nanotechnology is based on the prefix ‘nano’ which means 10^{-9} or one billionth of something (Joseph and Morrison, 2006). Nanotechnology is the manipulation or self-assembly of individual atoms, molecules, or molecular clusters into structures to create materials and devices with new or vastly different properties (Joseph and Morrison, 2006).

Several countries utilize this emerging technology and are implementing plans called the National Nanotechnology Initiative (NNI) as a means of prolonging economic growth. These countries include the USA, Japan, China, India, Brazil and South Africa. At present, the USA is leading in investing in their NNI with a 3.7 billion dollar investment in 4 years, followed by Japan and the European Union, and then China (Joseph and Morrison, 2006; Buentello et al, 2005). Other countries which have NNI plans are: Australia, Canada, Denmark, Finland, France, Germany, Israel, Italy, Korea, Malaysia, Mexico, Netherlands, New Zealand, Norway, Philippines, Singapore, Sweden, Switzerland, Thailand, Taiwan, and the UK (nanotechproject.org)

2.2 THE APPLICATIONS AND ADVANTAGES OF NANOTECHNOLOGY IN FOOD AND AGRICULTURE.

In the food industry, it is used in making better, stronger packaging and healthier foods. Nano-particles in health foods are being created to transport nutrients to human cells more efficiently than before. In addition, it is believed that nano-materials can be made to block harmful nutrients

such as cholesterol and food allergens from reaching certain parts of the body (Kuzma and VerHage, 2006). Nanotechnology is also utilized in agriculture in the making of environmentally friendly pesticides and herbicides as well as for livestock to produce higher production without large doses of growth hormones. There are also nano-materials which detect and neutralize pathogens on livestock before the products reach consumers (Kuzma and VerHage, 2006).

Nanotechnology applications are already being considered and invested in by leading food companies such as Nestle, Kraft, Hershey, Heinz and Unilever. However, these companies have not openly released any products which contain nano-materials, according to their food labeling. Nanotechnology food products that are already on the market are: Canola Active Oil by Shemen Indutries, Nanoceuticals Slim Shake Chocolate by RBC Life Sciences Inc., and Nanotea by Shenzhen Become Ind.& Trade Co. Ltd. (nanotechproject.org)

Shemen Industries uses a technology called NSSL (Nano-sized self assembled structured liquids), which is a development of minute compressed micelles, which are called nanodrops. These minute micelles serve as a liquid carrier, which allows penetration of healthy components (such as vitamins, minerals and phytochemicals) that are insoluble in water or fats. The micelles are added to the food product, and thus pass through the digestive system effectively, without sinking or breaking up, to the absorption site. The minute micelles carry the phytosterols to the large micelles that the body produces from the bile acid, where they compete with cholesterol for entry into the micelle. The phytosterols enter the micelle, thereby inhibiting transportation of cholesterol from the digestive system into the bloodstream. This advanced technology was applied in the development of Canola Active oil, produced by Shemen Industries (nanotechproject.org)

Nanoceuticals Slim Shake Chocolate is produced by using the natural health benefits of cocoa with RBC's NanoCluster™ delivery system to give you CocoaClusters a technologically advanced form of cocoa that offers enhanced flavor without the need for excess sugar. RBC's NanoClusters are tiny particles, 100,000th the size of a single grain of sand, and they are designed to carry nutrition into your cells. (nanotechproject.org)

Prepared with nanotechnology, the Nanotea can release effectively all the excellent essences of the tea, thus boosting the adsorption (adsorbing viruses, free radicals, cholesterol and blood fat) and annihilation of viruses through penetration so that a good supplement of selenium can be achieved and the selenium supplement function can be increased by 10 times. (nanotechproject.org)

2.3 THE CONTROVERTIAL HEALTH EFFECTS AND DISADVATGES OF NANOTECHNOLOGY.

Human exposure to nano-particles has been a controversial topic of discussion and investigation for decades. The potential routes of nano-particle exposure are inhalation, dermal, oral and in the case of biomedical applications, parenteral (Stern and McNeil, 2007). Studies that examine nano-particle exposure are rare and were not found during research. Therefore with the emerging technology being utilized in varying fields including the food industry, studies based on nano-particle exposure and toxicology are needed.

Exposure to toxic levels of nano-particles are said to be related to respiratory, neurological and gastrointestinal disorders to the exposed person (Stern and McNeil, 2007). "Nanoparticles of 50 and 70 nm can enter cells and lungs, respectively, while those of 30 nm can even pass through

the blood and brain barriers (ETC Group, 2006). They could then translocate from respiratory system to blood circulatory system, distributed throughout the body, and further taken up into liver, spleen, bone marrow, heart, brain, and other organs" (Kreyling et al., 2002; Oberdo¨rster et al., 2002; Oberdo¨rster et al., 2005) (Chau et al, 2007)

Nanotoxicity can also affect the health and safety of the industrial workforce, which are persons working in direct exposure to nano-particles. Regulations for the amounts of nano-particles used in products and the exposure of nano-particles to humans have not been determined by regulatory agencies, let alone an internationally accepted definition for nanotechnology. Without significant efforts to establish technologies and best practices in laboratories and work environments, the quality of life of the workforce may be affected because of potential adverse health effects of these new materials (Gednaidy and Karwowski, 2006).

2.4 OTHER APPLICATIONS OF NANOTECHNOLOGY.

Nanotechnology is utilized in a variety of fields including medicine, consumer products, water treatment, air pollution, energy conservation, information technology, and the military. A variety of consumer products can be made with the application of nanotechnology. For example, body lotions, sun screen lotion, make-up, cleaning detergents, clothing, sports gear, hair dryers and curling irons are just a few of the many products that can be produced to work more efficiently and last longer. (nanotechproject.org)

More efficient drug delivery systems in pharmaceutical drugs have made been possible due to this technology. Creation of nano-capsules and specialized outer coatings in drugs has allowed medicines to work in a proficient time release method (Buentello et al, 2005).

Water treatment processes has also benefitted from nanotechnology by allowing for more efficient water purification, desalination and detoxification, and detection of pathogens and contaminants. Creating light-weight nano-materials, catalyst and organic light-emitting devices have boosted energy efficiency, production and conservation. (Buentello et al, 2005).

Gas separating devices, and detoxification nano-materials detect pathogens in the atmosphere reduce air pollution. Nuclear weapons, military clothing, and vehicles are made with nanotechnology to resist rough terrain and conditions (Buentello et al, 2005).

2.5 PERCEPTION AND AWARENESS OF NANOTECHNOLOGY

Studies on perception and awareness of nanotechnology conducted in the Caribbean or on Caribbean people were not found during research. However, studies were found to be done American populations and Swiss populations.

"Public awareness of nanotechnology remains low, with three in four adults saying that they have heard just a little or nothing at all about it" (Hart, 2008). This survey was conducted on American respondents and does not reflect Trinidadian perception. The study also found that awareness of nanotechnology is greatest among men, especially under the age of 50 and lowest among women ages 50 and under (Hart, 2008). Household incomes, education levels and ethnicity were among other factors taken into account in this study. Respondents were also asked to state from what source they heard of nanotechnology.

"Nearly half of adults are too unsure about nanotechnology to make an initial assessment on the tradeoffs between risks and benefits. Of those willing to make a judgment, by three to one they think that benefits will outweigh risks (20%) as opposed to thinking risks will outweigh benefits (7%). The plurality, however, believe that risks and benefits will be about equal (25%)" (Hart, 2008).

Another study conducted on American respondents also found that awareness of nanotechnology was low with 81% of subjects reporting having heard nothing at all about it (Kahan et al, 2007). Fifty three percent were found to view benefits as outweighing risks and men (59% to 36%) are significantly more likely than women (47% to 40%) to think that risks outweigh benefits (Kahan et al, 2007).

Ethnicity was factored into this study; however income and education level was not. The respondents were recruited rather than randomly selected.

A study based on nanotechnology foods and food packaging examined 153 Swiss subjects willingness to buy these products. Information on nanotechnology applications to food packaging, bread, juice and tomatoes were given and subjects were asked to rate the benefits and risks on a 5-point scale ranging from 1 (no benefit/risk at all) to 5 (very high benefit/risk) (Siegrist et al, 2007).

Willingness to buy was also measured on a 5-point scale ranging from 1 (not at all) to 5 (absolutely). Social trust in institutions utilizing nanotechnology was also measured on a 5-point scale ranging from 1 (no trust) to 5 (very high trust) (Seigrist et al, 2007).

"Results found that subjects were hesitant to buy nanotechnology foods or food with nanotechnology packaging. However, nanotechnology packaging was perceived as being more beneficial that nanotechnology foods. A further result found that social trust in the food industry is an important factor in influencing the affect invoked by these new products" (Siegrist et al, 2007).

A similar result was found in a study on 337 German-speaking Swiss people where 19 nanotechnology applications were examined. The study results suggested that nanotechnology food packaging was assessed as less problematic than nanotechnology foods by subjects (Siegirst et al, 2008). Individual data showed that the importance of naturalness in food products and trust were significant factors influencing the perceived risks and benefits of nanotechnology foods and packaging (Siegrist et al, 2008). This study concluded that test subjects were of high status and level of education which suggested that these persons perceived less environmental health risks compared to low status persons. The study, therefore could have underestimated perceived risks related to nanotechnology (Siegrist et al, 2008).

The public's concerns associated with nanotechnology are related with perceived risks. A study conducted on 152 randomly selected participants from across three different cities in the US found that 17% of them were most concerned with nanotechnology being used by the military and 'evil doers' (Miller, 2008; Macoubrie, 2006). The participants of the study expressed low confidence in governments to manage technology risks to benefit the public interest and also expressed a firm desire for greater openness in all aspects of nanotechnology decision making (Miller, 2008). Labeling was also highlighted as important for consumers to identify the presence of nano-ingredients in foods (Miller, 2008).

Another perception study focused on scientist's perception and the media's portrayal of nano-particle safety. This study investigated how nanotechnology was depicted in the British newspaper press over a time period and also considered the views of nanotechnology scientists and journalists of the press (Wilkinson et al, 2007).

The scientists and journalists interviewed for this study believed that the most prominent risk issue was nano-particle safety; however this issue received little attention in the press (Wilkinson et al, 2007). They also showed concern about the regulation of pertinent applications before possible health risks become a controversial issue (Wilkinson et al, 2007).

Another important finding of the study was that news coverage tended to focus upon general ricks rather than more specific potential dangers, especially with regard to environmental impacts (Wilkinson et al, 2007; Friedman and Egolf, 2005). Some newspapers offered a fairly even treatment of possible risks and benefits of nanotechnology, whereas others emphasized the positives (Wilkinson et al, 2007).

3.0 METHODOLOGY

3.1 RESPONDENTS

The UWI student population was selected as the target population for the study. An approximation of 1% of 11,621 students, the total number of students enrolled in the years 2008-2009 were used to estimate an appropriate sample size. (UWI undergraduate degree programs)

Criteria for participation in this study entailed: students between the ages of 18 and 55, enrolled in the University of the West Indies, St. Augustine. This sample population comprised students of the faculties of engineering, law, medical sciences, science and agriculture, social sciences, and humanities and education. Undergraduate and post-graduate students as well as full-time, part-time and evening enrollment were not necessary criteria and therefore not determined in this study.

Questionnaires were distributed to university students on the main campus grounds as well as Mount Hope, in highly 'student-active' locations. Students were randomly selected in all areas: SAC, LRC, Engineering undercroft, UWI food court, and Mount Hope library. A total of 145 students volunteered willingly upon being asked in answering and completing the questionnaires. The number of participants from each faculty was as follows: Science and Agriculture- 49, Engineering- 17, Humanities and Education- 22, Social Sciences- 34, Law- 9, Medical Sciences- 14. Therefore there were a total number of 145 participants in this study.

3.2 QUESTIONNAIRE

The questionnaire (see appendices) comprised 18 questions which were divided into four sections: demographics, awareness of nanotechnology and food consumption and nutrition education.

The section on demographics comprised three questions: age, faculty of enrollment and gender.

The section of awareness of nanotechnology comprised 13 questions. It included a general, simplified definition of nanotechnology and about the various uses the technology can be applied to. Students were asked if they ever heard about nanotechnology and it various applications to the food industry. In questions 10 and 11 respectively, four benefits and four risks associated with nanotechnology were listed in point form for the participant. Students were asked if they were aware of these, and if the risks overweighed the benefits. Included in this section also, were questions about trust in government laws and local food manufacturers, as well as willingness and reasons to purchase and consume nanotechnology foods.

The final section of food consumption and nutrition education comprised two questions which asked about the participants' comprehension of the Nutrition facts panel on food labels, and about the factors that are most important when buying food.

The questionnaire was pre-tested on six university students who were chosen randomly at public locations on the university campus. The students were timed during the pre-test and estimated length of time was five minutes per questionnaire. Queries were noted and rectified. Five out of the six students determined that there were no issues with the questionnaire in terms of understanding the questions, and grammar and spelling. However, one of the respondents had

issues comprehending question 14 due it being lengthy. The grammar of the question was modified and shortened for ease of comprehension.

A reliability test was carried out on three respondents out of the sample population using the test-retest method whereby the respondents answered the same questionnaire on two different occasions one week apart.

3.3 STATISTICAL ANANLYSIS

The data collected was analyzed using SPSS Statistical software version 17 for window, Chicago, Illinois, 2003 as well as Windows Excel, 2007. Distribution frequency and chi square tests were the methods used to analyze data and to prove or disprove the hypotheses.

4.0 RESULTS

This study found that 75.2% of the sample university students claimed to have heard of nanotechnology prior to the questionnaire and 24.8% were not aware of nanotechnology (See appendix: Fig 1).

4.1 AWARENESS OF NANOTECHNOLOGY, APPLICATIONS AND RISKS AND BENEFITS.

Of the 145 university students that participated in this study, 55 were males and 90 were females and the majority of students fell into the age group 18-24 (See appendix: Table1). Those respondents who have not heard of nanotechnology were omitted from data analysis. Thus the 109 respondents who claimed to have heard of nanotechnology prior to the questionnaire were analyzed. Most students (37.2%) answered they had heard a little about it (See appendix: Fig2).

The respondents of the science and agriculture faculty were shown to have been most aware since 32.1% of these students answered positively to having heard about nanotechnology prior to the questionnaire. The faculty least aware was the law faculty, with 7.3% of these students having heard of nanotechnology (See appendix: Fig 3). In this sample population, nanotechnology awareness is greater among women than men, where 56% of women claimed to have heard of nanotechnology versus the 44% of men (See appendix: Fig4).

When it comes to the application of nanotechnology in the food industry, 63 respondents (57.8%) claim to be familiar (See appendix: Table 2 and Fig 6). Food packaging was the most popular application chosen among the respondents who were familiar (See appendix: Table 4).

Nanotechnology applications to fields other than the food industry seem to be more popular among the sample of university students. The study found that 80 respondents (73.4%) claimed to be familiar with the roles of nanotechnology in other fields (See appendix: Fig7). Respondents claimed to be aware of a combination of fields rather than choosing just one. Many respondents associated nanotechnology with cancer treatment and information technology (See appendix: Table 5).

The majority of the sample population aware of nanotechnology did not seem to be aware of the risks and benefits associated with the technology. Table 2 of the appendix shows that on 27 respondents (24.8%) were aware of the health risks and 43 respondents (39.4%) were aware of the benefits.

4.2 PERCEPTION AND ATTITUDES TOWARDS RISKS AND BENEFITS, FOOD LAWS AND FOOD MANUFACTURERS AND INTENT TO PURCHASE.

Perception of nanotechnology risks and benefits were assessed by questioning if risks overweighed benefits. The study found that 45 respondents (41.3%) believed that risks overweighed the benefits, while 23 respondents (21.1%) answered 'no' to risks overweighing benefits. Those who perceived benefits and risks as equal consisted 7.3% of the sample population and 30.3% were not sure if risks overweighed benefits (See appendix: Table 3 and Fig8). More females (60%) than males (40%) perceived risks as overweighing benefits (See appendix: Fig 18). Chi square =0.507, p= 0.477>0.05 which is insignificant. This implies that the hypothesis that males are more likely than females to think that risks overweigh benefits is rejected and therefore there is no relationship between gender and perceived risks overweighing benefits.

Majority of the sample population (71.1%) who perceived risks as overweighing benefits had no intent to purchase nanotechnology foods (See appendix: Fig 17). Chi square =4.195, p= 0.41<0.05 which is significant and accepts the hypothesis that those who perceive risks as overweighing benefits has less intent to purchase nanotechnology foods.

The intent to purchase nanotechnology foods was found to be willing by 44 respondents (40.4%) and not willing by 65 respondents (59.6%) of the sample (See appendix: Fig 9 and Table 3). Respondents were also asked for what reasons they would or would not purchase nanotechnology foods. The study found that 39.4% of the sample population would not consume nanotechnology foods due to health safety concerns, 18.3% said they would not consume due to lack of trust in food manufacturers while 31.2% said they would consume because of the benefits (See appendix: Fig10).

The majority (66.1%) of the sample still needed more information to make a decision about the effect nanotechnology would have on the food industry in Trinidad. However, 21 respondents (19.3%) said that it would have a negative effect while 16 respondents (14.7%) said it would have a positive effect (See appendix: Fig 11 and Table 3).

The respondents' nutrition knowledge was examined to investigate if this would affect the intent to purchase nanotechnology foods. A total of 51 respondents (46.8%) claimed the information on the nutrition facts panel was easy to understand (See appendix: Fig 12 and Table 6). Figure 12 reveals that comprehension of the nutrition facts panel does affect the intent to purchase nanotechnology foods since more than half of the respondents from each group did not intend to buy and consume these types of foods.

The majority of the sample population considers safety and taste most important when buying foods (See appendix: Table 7 and Table 8). Importance of safety when buying foods seemed to have a greater impact on intent to purchase nanotechnology foods. All respondents who thought safety as unimportant when buying foods intended to purchase nanotechnology foods while 60% and 61% of respondents who selected safety as 'fairly important' or 'very important' respectively had no intent to buy nanotechnology foods (See appendix: Fig 13).

All respondents who rated taste as unimportant when buying foods had no intent to purchase and consume nanotechnology foods and 55.6% and 61.1% of respondents who considered taste fairly and very important respectively also had no intent to purchase nanotechnology foods (See appendix: Figure 14).

The sample population's trust in food laws was depicted as low since the majority of the population (79.8%) does not think that Trinidad has effective food laws to protect consumers from potentially hazardous foods. Majority of respondents (72.5%) also do not believe that food manufacturers abide by the food laws of Trinidad to prevent risks to foods (See appendix: Table 3). The chi square value is inconsistent with the results due to two or more cells in the analysis containing less than five respondents. However using frequency distribution analysis, the results support the hypothesis that persons with low trust in food laws have no intent to purchase nanotechnology foods as shown in figure 15.

The intent to purchase nanotechnology foods based of belief in food laws and food manufacturers was similar since 60.9% and 65.8% of respondents who had no belief in food laws and food manufacturers respectively had no intent to purchase nanotechnology foods (See appendix: Fig 15 and Fig 16). Chi square =4.825, $p= 0.28<0.05$ which is significant. This implies

that the hypothesis that persons with low trust in food manufacturers have no intent to purchase nanotechnology foods.

The reliability test obtained a Cronbach's alpha value of 0.353 among the three respondents who were asked to perform answer the questionnaire twice. This value suggests that the variability of the sample was low.

5.0 DISCUSSION

Unlike other awareness and perception studies done in the US and Switzerland, this study found that nanotechnology awareness is high which is supported by the results of 75.2% of the sample population having heard of nanotechnology. High awareness may be attributed to differences in cultures and age group. The majority of university students in this sample fell into the age group 18-24 years and being university students may predispose this sample to more sources of information to learn about upcoming technologies. Comparative awareness and perception studies were carried out two to three years ago which may imply that any new information and advancements may have been exposed to the public since then. However, sources of information whereby nanotechnology was received cannot be confirmed since these were not determined in the study.

Awareness of the health risks was low in the sample population with just 24.8% saying they have heard of the risks. Awareness of the benefits seems to be slightly popular with 39.4% saying they heard of the benefits. There seems to be no association between the awareness of nanotechnology and the awareness of nanotechnology risks among the sample population. Determining what respondents do know about nanotechnology was not explored in the study but would given a clearer understanding about how knowledgeable the sample population was about the technology.

Awareness of nanotechnology differed among the various faculties. Results found that the faculty of Science and Agriculture had the highest percentage (32.1%) of the sample population

who has heard to nanotechnology when compared to other faculties. It can be assumed that respondents belonging to this faculty have a background in at least two sciences and may also be predisposed to information sources about nanotechnology. Those respondents with a food sciences background may also be aware to nanotechnology. A major limitation of this study was that a measure of 'how much' and 'how little' a respondent has heard was not determined. However, 48.6% of the sample population claimed to have heard a little about nanotechnology. This alleged 'little' information is the basis by which respondents make their judgments of risks and benefits associated with nanotechnology.

More respondents claimed to be familiar with nanotechnology applications in fields other than the food industry when compared to applications to food. Results found that 57.8% were familiar with role of nanotechnology in the food industry and 73.4% were familiar with its role in fields other than the food industry. The most popular application to the food industry was food packaging. Cancer treatment and information technology was the most applications in other fields.

The respondents' visceral reaction causes them to make judgments about nanotechnology risks and benefits (Kahan et al, 2007). Results showed that 41.3% of the population believed that nanotechnology risks overweighed benefits and 30.3% were not sure about risks overweighing benefits. Unlike results found in a study by Kahan et al in 2007 where men were significantly more likely than women to perceive risks as overweighing benefits, this study found that more females within the sample perceived risks as overweighing benefits. Therefore it can be assumed that there is no relationship between gender and perceived risks overweighing benefits. The study done by Kahan et al in 2007 was conducted on an American sample population. Therefore

differences in cultures may be attributed to the results found in this study. Cultural values and beliefs also play a role in decision making. Females may be more tentative and cautious with foods that they may associate with high risks.

Results did support the hypothesis based on results found by Siegrist et al in 2007 which agrees that those who perceive risks as overweighing benefits will have no intent to buy nanotechnology foods. It can be assumed therefore that negative perception of risks will affect the respondents' intent or willingness to buy and consume nanotechnology foods. However, perceived benefits can also have an impact on willingness to buy but was not measured. Acceptance of nanotechnology foods cannot be reduced to perceived benefits since consumers differ in what they perceive as benefits (Siegrist et al, 2007). Perceived risks play an important role in food purchasing and consumption decisions within the sample. However, a low level of perceived risks may not be sufficient reason to buy nanotechnology foods (Siegrist et al, 2007). Benefits perceived by the consumer will affect their intent to purchase.

Approximately 60% of the sample population had no intent to purchase nanotechnology foods. Along with perception of nanotechnology risks, belief in food laws and food manufacturers affected the intent to purchase and consume nanotechnology foods. According to frequency distribution and chi square tests results, those respondents who had no belief in food laws and food manufacturers also had no intent to purchase nanotechnology foods which corresponds with results found in similar studies by Siegrist et al in 2007 and 2008.

Food laws of Trinidad and Tobago may be different to foreign countries and awareness of food laws was not tested. The results revealed that 79.8% of the sample population did not believe that

Trinidad has effective food laws to protect the consumer from hazardous foods. A slightly smaller percentage of 72.5% believed that Trinidadian food manufacturers did not abide food laws to prevent and manage risks to foods during processing and manufacturing. The issue that is implied and that should be addressed is public trust in these institutions to manage and practice safe food handling policies. The sample population of this study seems to have low trust in these institutions. Therefore trust in institutions producing nanotechnology food is an important factor directly influencing the affect evoked by these new products and willingness to buy (Siegrist et al, 2007).

Intent to purchase and consume nanotechnology foods was also low in respondents who understood the nutrition facts panel easily. The reasons are unknown; however a relationship cannot be tested in this study since other factors such as perceived risks overweighing benefits and no belief in food laws and manufacturers may be attributed.

Intent to purchase based on importance of safety when buying foods was determined. Respondents who considered safety most important when buying food had no intent to purchase nanotechnology foods. It is possible that negative perception of nanotechnology risks, food laws and food manufacturers affects how a consumer views how safe a food may be to eat. Nanotechnology foods may hence be perceived as unsafe to these particular respondents.

The perception and acceptance of nanotechnology foods are based on various factors including the beneficial effects of nanotechnology, and the cultural, social and economic aspects of a country (Siegrist, 2007). Effective communication to the public is an essential aspect of the education process. Communication through the media and other sources will educate the public

and allow them to make informed decisions about this technology. Like every new technology to be developed, there is always public speculation associated with it. Results found that 66.1% of this sample population claimed they needed more information to make their decision about whether nanotechnology would have a positive or negative effect on the food industry if implemented in Trinidad.

Exposure of nanotechnology-related topics is rare in local media and thus information is lacking for public awareness to increase. The news and entertainment media are likely to play formative roles in shaping the parameters of public debate (Wilkinson et al, 2007). However, it is noted in an article by Wilkinson et al, 2001 which referenced Kasperson et al:

‘ The mass media cover risks selectively, according to those that are rare or dramatic- that is, that have more ‘story value’- disproportionate coverage while downplaying, or attenuating, more commonplace but often more serious risks. (Kasperson et al, 2001: 18)’

Therefore, media communication of information must not be selective for the sake of increasing knowledge and making informed judgments.

5.1 LIMITATIONS

- Nanotechnology perception and awareness studies that were conducted in Trinidad or the wider Caribbean were not found during research.
- When collecting data respondents may have given socially desirable responses which may or may not have been the truth.

- The survey instrument used in the present study limited the demographic information. Therefore, other types of information such as ethnicity, country of origin, program pursued and income level were not investigated.
- Depending on age groups and level of maturity, the respondents may have interpreted the questions differently. Items on the research instrument may have been constructed in a way that respondents did not understand.
- The questionnaire did not allow the respondent to identify the level they are enrolled in the university that is, postgraduate, undergraduate etc.
- In designing the questionnaire as quick and simple as possible for respondents, some applications to which nanotechnology can be applied were omitted from the definition. As well as some of the risks associated and the benefits of nanotechnology could not be added for more respondent information. Therefore the respondent may have had too little information to state their opinion.
- Sources of information from which nanotechnology was heard by the respondent was explored.
- Perception of other variables such as 'benefits overweighing risks' were not investigated.
- The sample size may not have been representative the entire university population.
- Limited time frame for planning and preparation for this study.
- Limitations of the test-retest method of reliability may have affected the Cronbach's alpha value. The sample size for the reliability test may be too small; testing conditions may vary results such as in a noisy environment, warm temperatures and inadequate lighting; the physical condition of the respondent on the day of retesting could affect the reliability.

5.2 RECOMMENDATIONS

- Socio-economic factors could have taken into account such as income and frequency of grocery shopping.
- More demographic factors could have been considered, such as ethnicity, country of origin and program pursued.
- The sample size could be increased.
- It is essential to develop strategies for communicating scientifically sound information about nanotechnology to make it possible for people of diverse values to draw the same factual conclusions from it. (Kahan et al, 2007).
- Other study designs can be used to conduct the study such as using a focus group rather conducting a survey.
- Examples of nanotechnology foods can be used as a reference for participants such as bread and juice such as in the study performed by Siegrist et al in 2007.

6.0 CONCLUSION

There is high awareness of nanotechnology among this sample population which may be related to demographic factors of age group and educational level. Overall, intent to purchase and consume nanotechnology foods is low and it may be related to the respondents' perception of risks overweighing benefits and no belief in food laws to safeguard the consumer against hazardous foods. Low intent to purchase nanotechnology foods is also related to low trust in local food manufacturers' compliance with food safety regulations during food processing and packaging. Those respondents who considered safety most important when buying food also had no intent to purchase nanotechnology foods most likely linked to low social trust in food institutions.

The respondents of this study expressed the need for more information to decide whether nanotechnology will have a positive or negative effect on the food industry in Trinidad. This implies that there is a lack of mass media circulation of information related to nanotechnology and risks and benefits. Information should not be selected towards the portrayal of risks or benefits only, but rather the most common and most serious risks and benefits that nanotechnology has to offer.

7.0 APPENDICES

Table 1. Demographics of the university sample population

Variable	**n**	**%**
Gender		
Male	55	37.9
Female	90	62.1
Total	145	100
Age		
18-24	127	87.6
25-34	17	11.7
35-45	1	0.7
Total	145	100
Faculty		
Science &Agri	49	33.8
Engineering	17	11.7
Hum&Ed	22	15.2
Social Science	34	23.4
Law	9	6.2
Med. Sci.	14	9.7
Total	145	100

n = number of respondents

% = percent of n

Table 2. Respondents who are aware of nanotechnology and risks and benefits

Variable	**n**	**%**
Heard of nanotechnology	109	75.2
How much have you heard		
Heard a lot it	14	12.8
Heard some about it	42	38.5
Heard a little about it	53	48.6
Familiar with the role in food	63	57.8
Familiar with the role in other fields	80	73.4
Aware of health risks	27	24.8
Aware of benefits	43	39.4

n = number of respondents

% = percent of n

Table 3. Attitudes and perception of risks overweighing benefits, food laws, food manufacturers and nanotechnology

Variable	**n**	**%**
Risks overweigh benefits		
Yes	45	41.3
No	23	21.1
Belief in food laws		
Yes	6	5.5
No	87	79.8
Belief in food manufacturers		
Yes	10	9.2
No	79	72.5
Intent to purchase		
Yes	44	40.4
No	65	59.6
Affect of nanotechnology		
Positive	16	14.7
Negative	21	19.3
Need more info.	72	66.1

n = number of respondents

% = percent of n

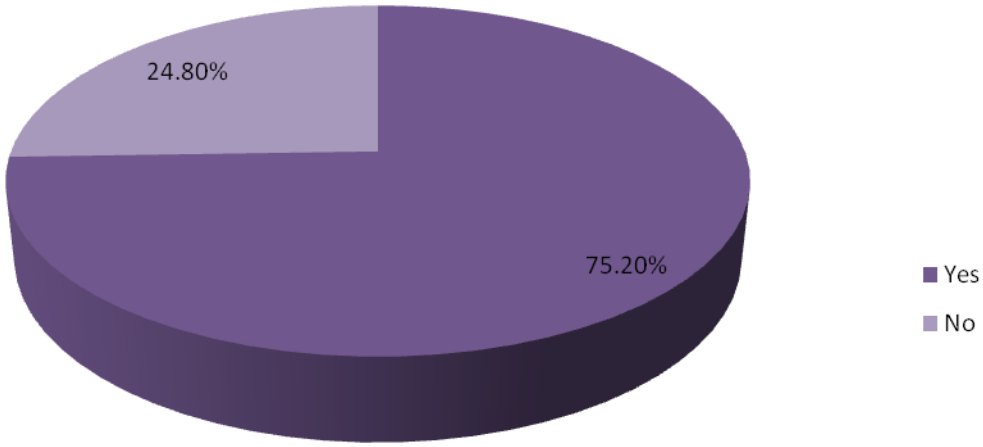


Fig.1 Population of the sample who has heard of nanotechnology in the university

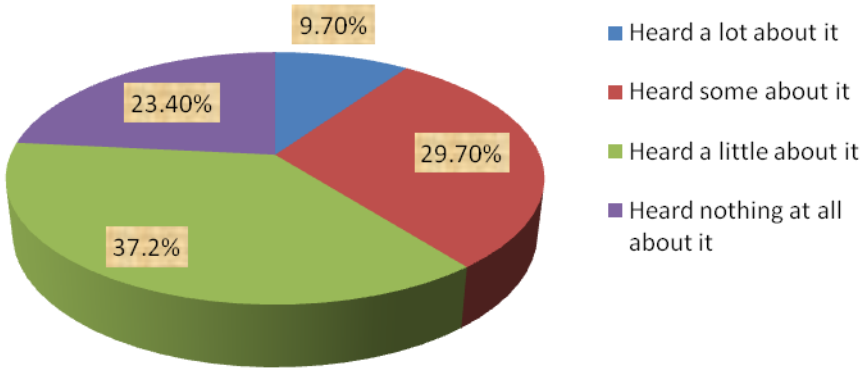


Fig 2. Population of the sample for how much they have heard of nanotechnology

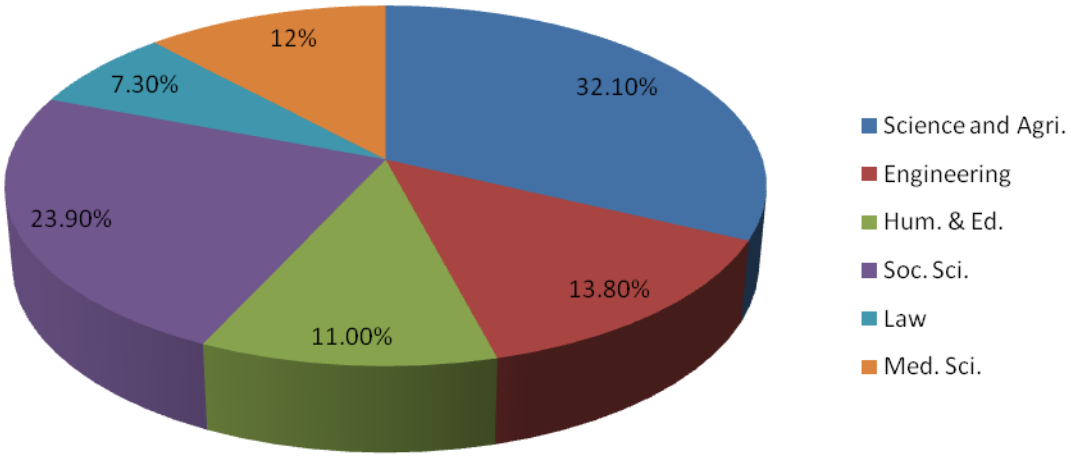


Fig. 3 Awareness of nanotechnology among the various faculties of the university

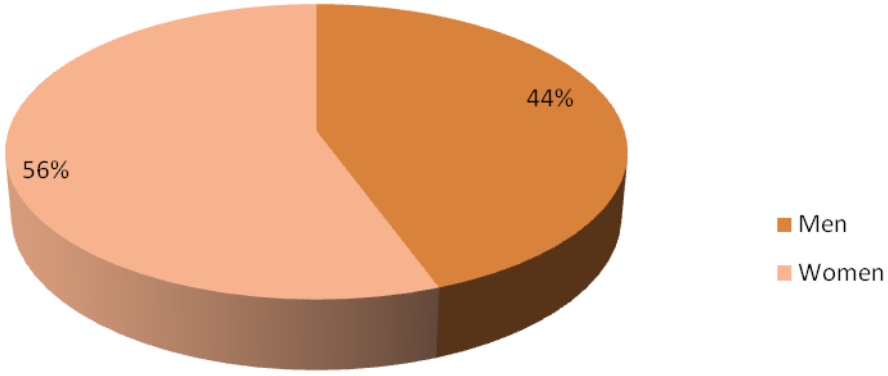


Fig 4. Men and women who has heard of nanotechnology.

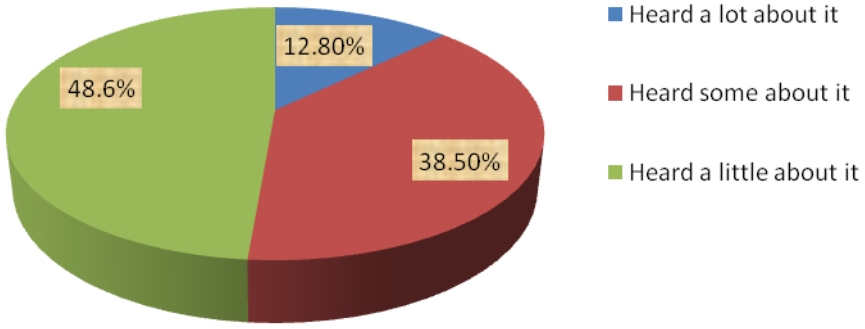


Fig 5. Respondents aware of nanotechnology and how much they have heard about it

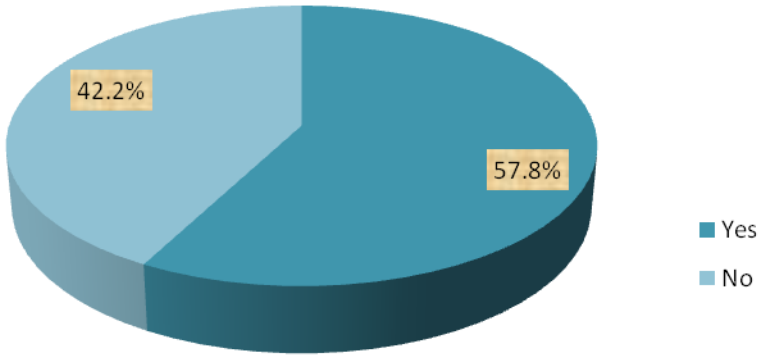


Fig 6. Respondents who are aware of nanotechnology and familiar with its role in the food industry

Table 4. Respondents who are aware of the role of nanotechnology in food production

Role in food production	**n**	**%**
Food packaging	21	19.3
Artificial ingredients	8	7.3
Artificial flavors	3	2.8
Preservatives	6	5.5
Food packaging & artificial ingredients	4	3.7
Food packaging & articial flavors	1	0.9
Food packaging & preservatives	4	3.7
Artficial ingredients & artficial flavors	2	1.8
Artificial ingredients & preservatives	4	3.7
Food packaging, artificial ingredients, flavors &preservatives	2	1.8
Artificial ingredients, flavors & preservatives	2	1.8
Food packaging, artificial ingredients & flavors	5	4.6
I do not know any	47	43.1
Total	109	100

n = number of respondents

% = percent of n

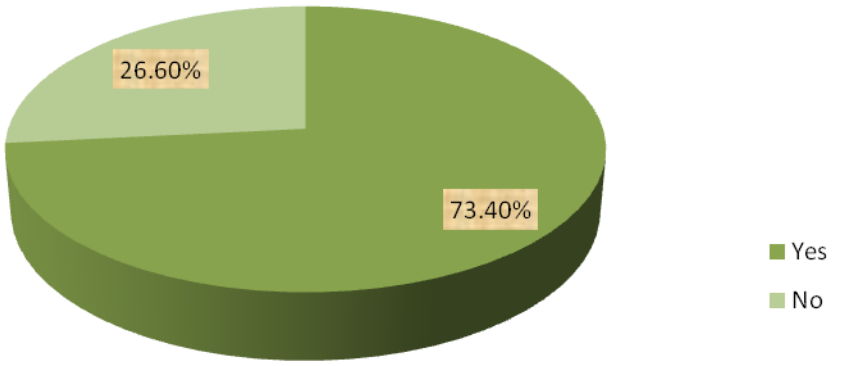


Fig 7. Respondents who are aware of nanotechnology and familiar with its role in fields other than the food industry

Table 5. Respondents who are aware of the role of nanotechnology in fields other that the food industry

Role in other fields	n	%
Cancer treatment	12	11
Information technology	19	17.4
Heavy industry	6	5.5
Cancer treatment & energy efficiency	1	0.9
Cancer treatment & information technology	21	19.3
Cancer treatment & heavy industry	1	0.9
Cancer treatment & other	1	0.9
Energy efficiency & information technology	4	3.7
Information technology & heavy industry	2	1.8
Information technology & other	1	0.9
Cancer treatment, energy efficiency & information technology	5	4.6
Cancer treatment, information technology & heavy industry	4	3.7
Cancer treatment, heavy industry & other	1	0.9
Cancer treament, energy efficiency & heavy industry	3	2.8
Other	1	0.9
I am not familiar with any	27	24.8
Total	109	100

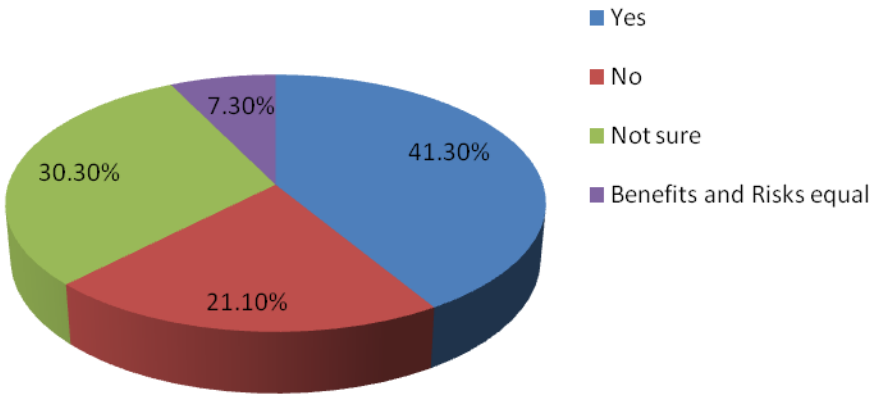


Fig 8. Perception of nanotechnology risks overweighing benefits in the population who are aware of nanotechnology

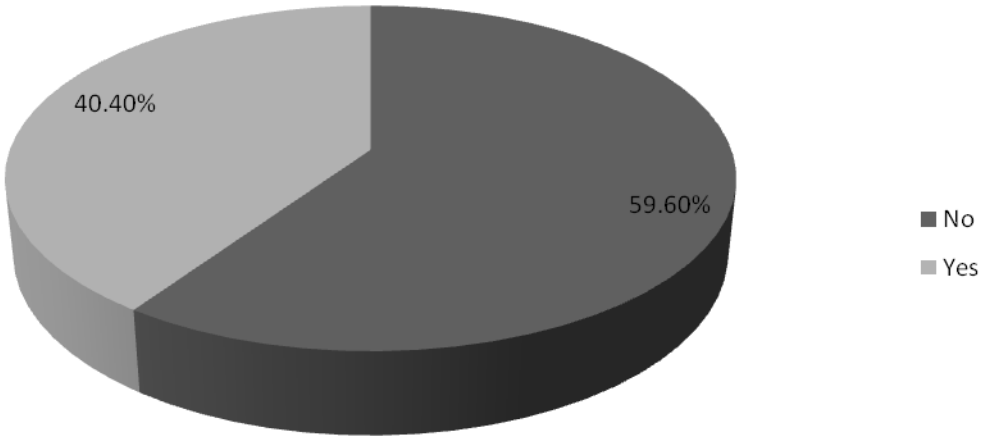


Fig 9. Intent to purchase nanotechnology foods in the population who are aware nanotechnology

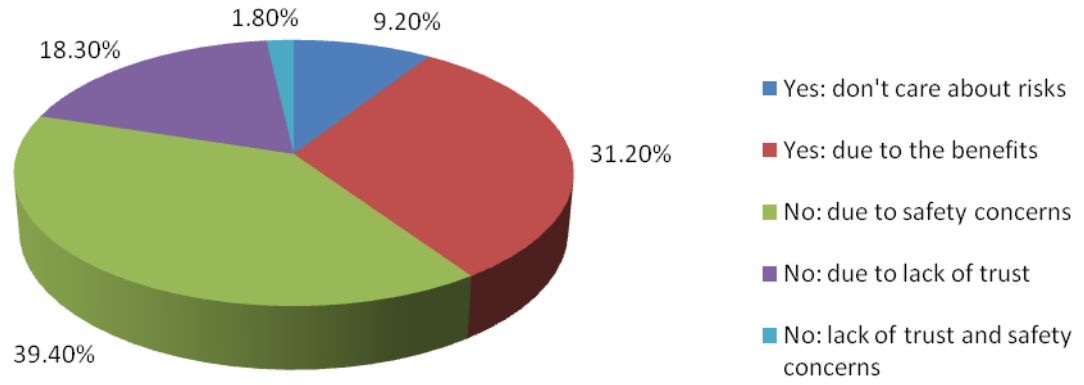


Fig.10 Intent to purchase nanotechnology foods for the following reasons in the population who are aware of nanotechnology

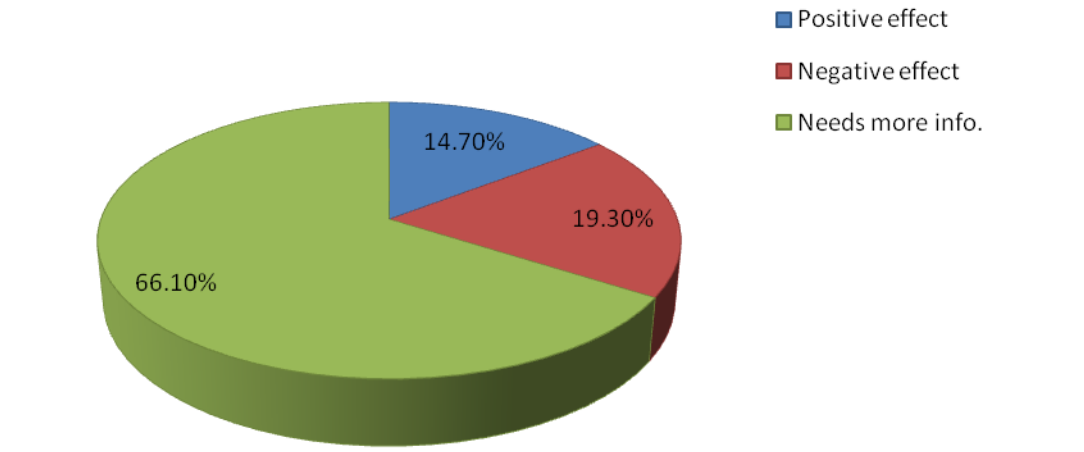


fig 11. Perception of implementing nanotechnology in Trinidad in the population who are aware of nanotechnology

Other results:

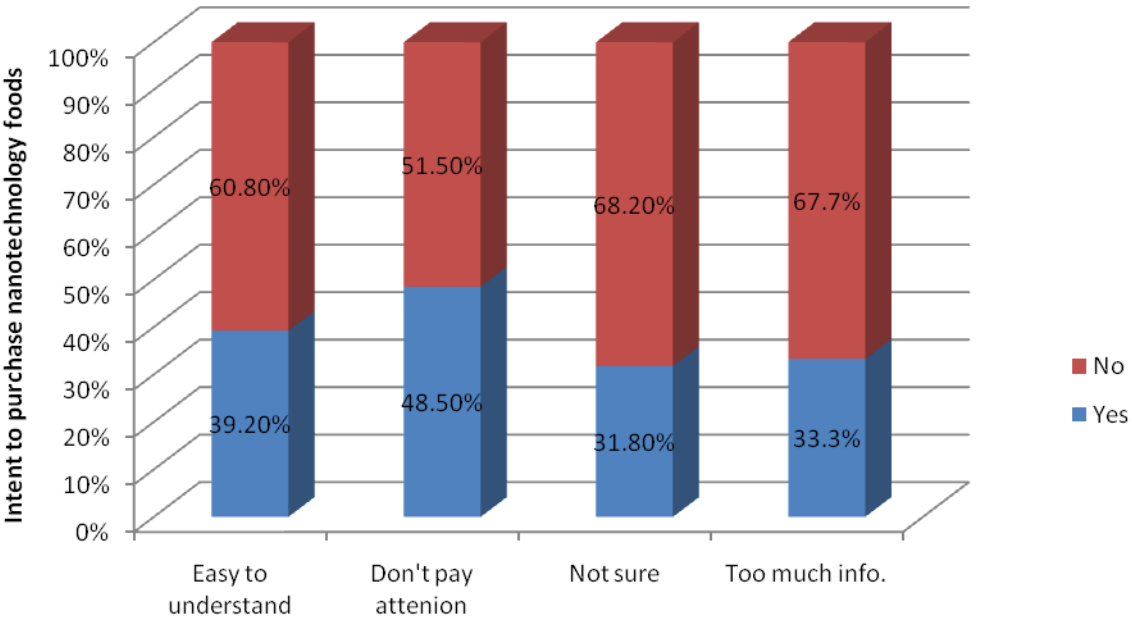


Fig. 12 Intent to purchase nanotechnology foods based on comprehension of the nutrition facts panel in the population who are aware of nanotechnology

Table 6. Number of respondents' intent to purchase nanotechnology foods based on nutrition understanding of the nutrition facts panel

	Intent to purchase nanotechnology foods		
Nutrition facts panel comprehension	Yes	No	Total
Info is easy to understand	20	31	51
Don't really pay attention	16	17	33
Not sure how to use this info	7	15	22
Too much info	1	2	3
Total	44	65	109

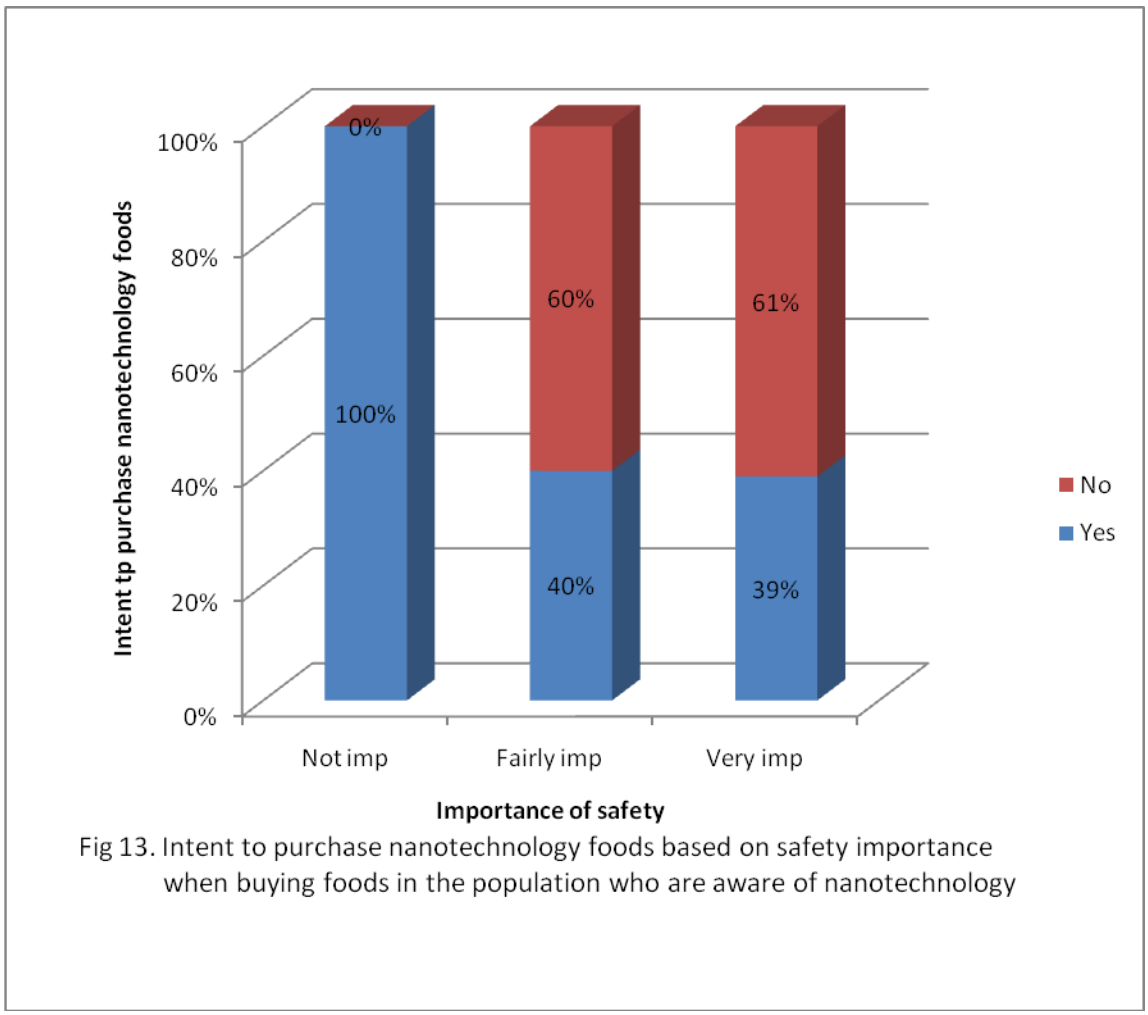


Fig 13. Intent to purchase nanotechnology foods based on safety importance when buying foods in the population who are aware of nanotechnology

Table 7. Number of respondents' intent to purchase nanotechnology foods based on importance of safety when buying foods

	Intent to purchase nanotechnology foods		
Importance of safety	Yes	No	Total
Not important	2	0	2
Fairly important	12	18	30
Very important	30	47	77
Total	44	65	109

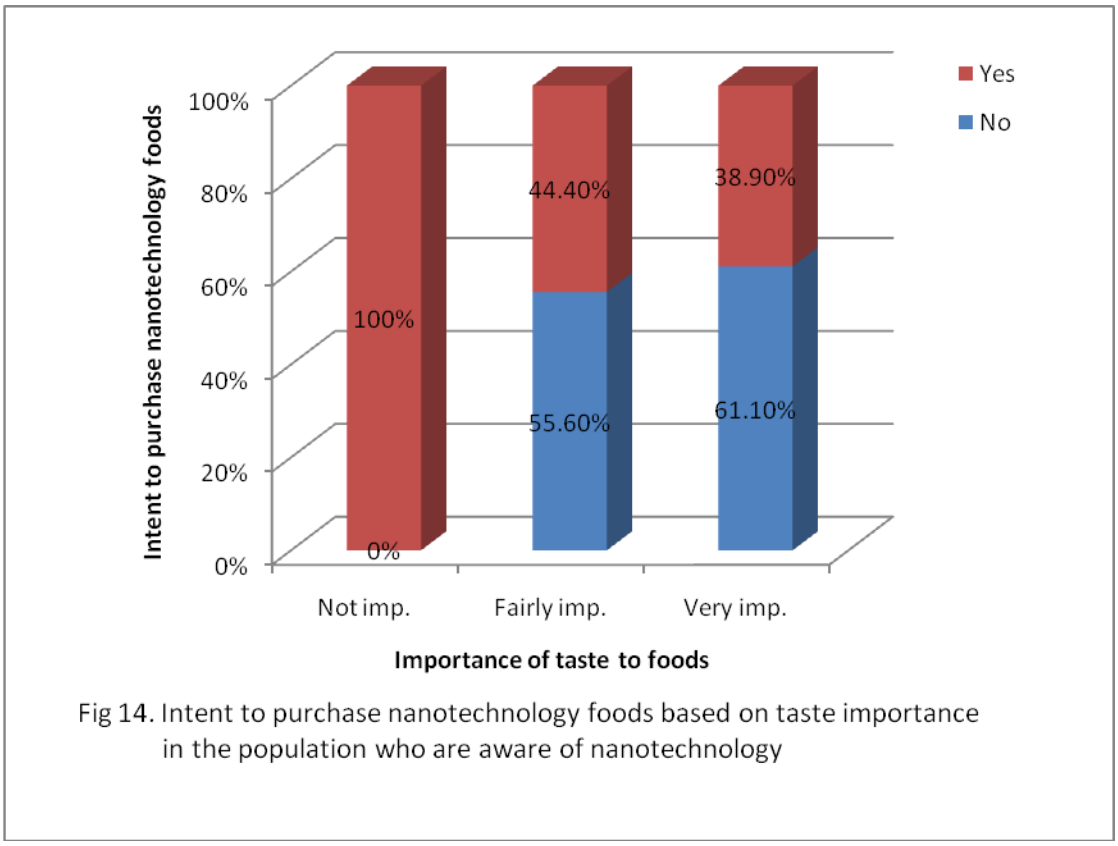


Fig 14. Intent to purchase nanotechnology foods based on taste importance in the population who are aware of nanotechnology

Table 8. Number of respondents' intent to purchase nanotechnology foods based on importance of taste when buying foods.

	Intent to purchase nanotechnology foods		
Importance of taste	Yes	No	Total
Not important	1	0	1
Fairly important	8	10	18
Very important	35	55	90
Total	44	65	109

HYPOTHESIS 1:

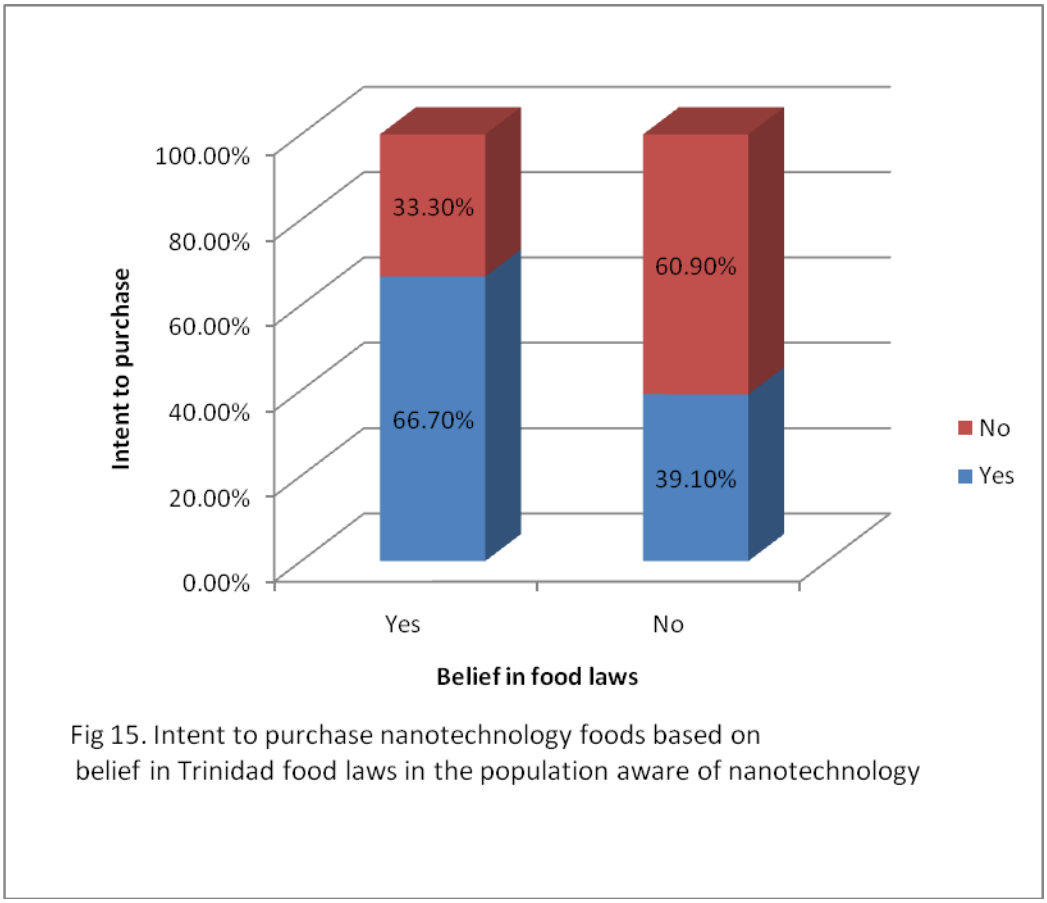


Fig 15. Intent to purchase nanotechnology foods based on belief in Trinidad food laws in the population aware of nanotechnology

The chi square= 1.768, p=0.184>0.05 is inconsistent with the results because there were less than 5 respondents in the group who claimed to have belief in food laws. However using frequency distribution analysis, the results support the hypothesis that persons with low trust in food laws have no intent to purchase nanotechnology foods.

Table 9. Number of respondents' intent to purchase nanotechnology foods based on belief in Trinidad food laws

	Intent to purchase nanotechnology foods		
Belief in food laws	Yes	No	Total
Yes	4	2	6
No	34	53	87
Total	38	55	93

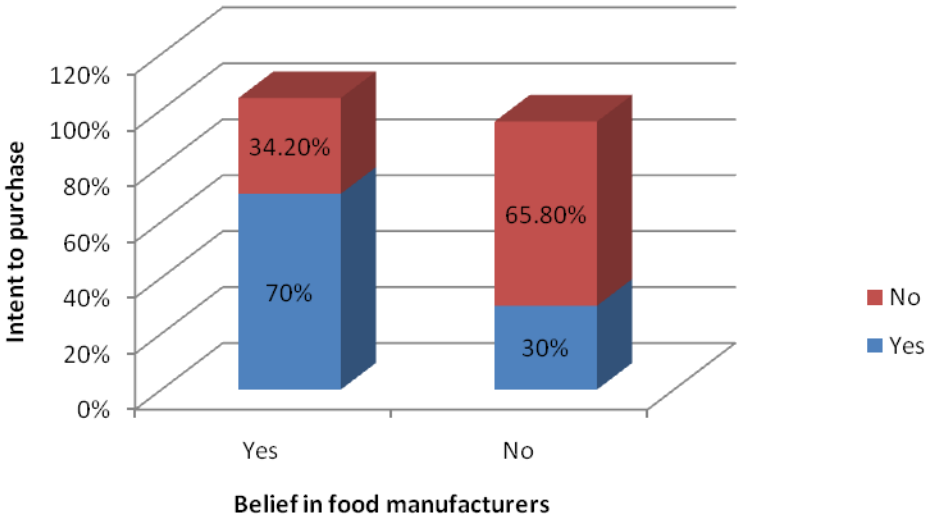


Fig 16. Intent to purachase nanotechnology foods based on belief in food manufacturers in the population aware of nanotechnology
Chi square= 4.825
p = 0.28<0.05

Chi square =4.825, p= 0.28<0.05 which is significant. This implies that the hypothesis that persons with low trust in food manufacturers have no intent to purchase nanotechnology foods.

Table 10 Number of respondents' intent to purchase nanotechnology foods based on belief in food manufacturers

	Intent to purchase nanotechnology foods		
Belief in food manufacturers	Yes	No	Total
Yes	7	3	10
No	27	52	79
Total	34	55	89

HYPOTHESIS 2

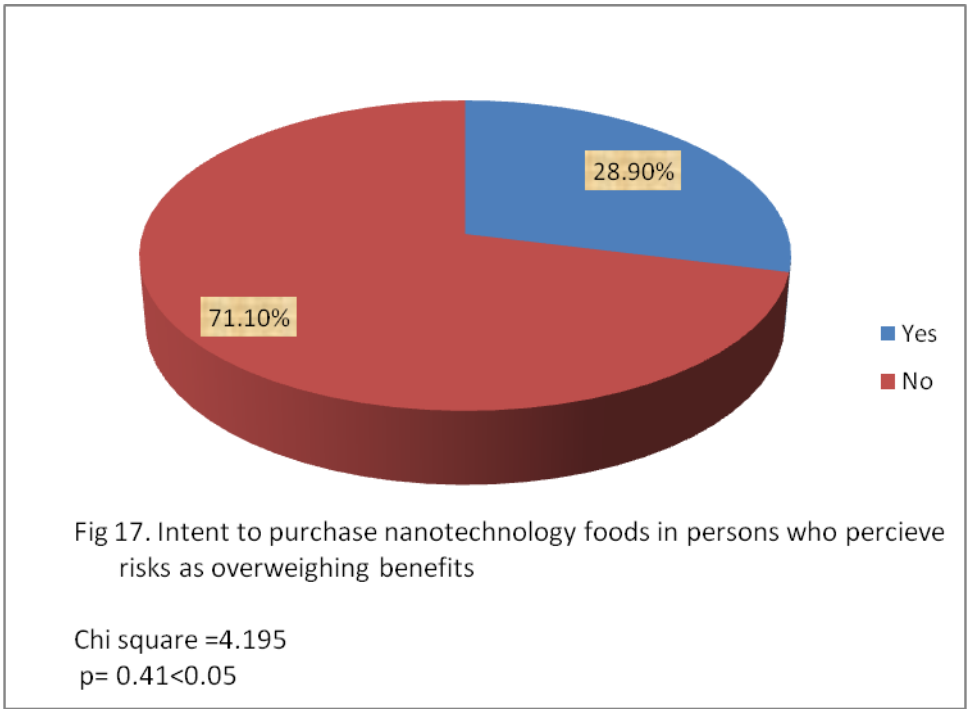


Fig 17. Intent to purchase nanotechnology foods in persons who percieve risks as overweighing benefits

Chi square =4.195
p= 0.41<0.05

Chi square =4.195, p= 0.41<0.05 which is significant and accepts the hypothesis that those who perceive risks as overweighing benefits has less intent to purchase nanotechnology foods.

Table 11. Number of respondents' intent to purchase based on perception of risks overweighing benefits

	Intent to purchase nanotechnology foods		
Risks overweigh benefits	Yes	No	Total
Yes	13	32	45
No	14	9	23
Not sure	13	20	33
Beneifits and risks equal	4	4	8

HYPOTHESIS 3

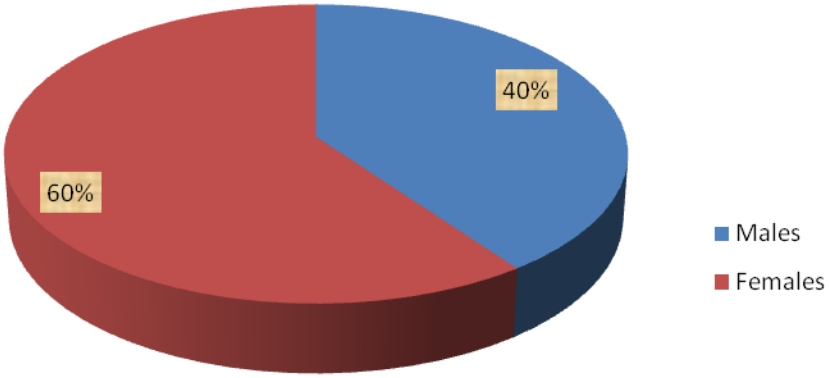


Fig 18. Distribution of males and females who percieve risks as overweighing benefits in the population who are aware of nanotechnology

Chi square =0.507
p= 0.477>0.05

Chi square = 0.477>0.05 which is insignificant. This implies that the hypothesis that males are more likely than females to think that risks overweigh benefits is rejected.

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