SENSORY ACCEPTABILITY OF VEGAN INGREDIENT SUBSTITUTIONS IN ICE CREAM

by

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SENSORY ACCEPTABILITY OF VEGAN INGREDIENT SUBSTITUTIONS

IN ICE CREAM

Project Approved:

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ABSTRACT

Introduction: A vegan diet is defined as avoiding the consumption and/or use of meat, fish, poultry or any animal-derived product. Vegans generally have a lower serum cholesterol, body mass index, blood pressure, and risk of heart disease than meat eaters. It is important to use fat substitutions such as dairy and/or egg replacements with vegan recipes. In ice cream, a product mainly composed of: cream, milk solids, sugar, and water, vegetable fat substitutions are often utilized. Fat replacers must contain similar structural components to milk fat to preserve texture and mouthfeel.

Objective: Because of the growing popularity of vegan diets, this research project studies the texture, flavor, and eye appeal of vegan ingredient substitutions for ice cream. The purpose of this study is to measure the public's reactions and ratings of these substitutions and to identify which ingredients act as the best replacements.

Study Design: The research was collected in a single-blind, cross-sectional study design. 54 students, who were enrolled in one of the two chosen courses under the TCU Nutritional Sciences department, were asked to participate in an experimental sensory evaluation session to complete assessment of 3 different samples of vegan ice cream. Sample A was made using coffee, cashews and coconut cream, B used coconut cream and dates, and sample C used coconut milk. The evaluations took place on two separate occasions in the Annie Richardson Bass Building kitchens. The following were assessed: flavor, sweetness, texture, mouthfeel, eye appeal, color, and overall rating of vegan ingredient substitutions for ice cream recipes. Sensory criteria results from students ranking responses were analyzed using SPSS XIX. Frequency distributions, ANOVAs, correlations, and descriptive statistics were determined to meet study objectives ($p<0.05$).

Results: Based on the analysis of the results from the sensory test, 53% of participants preferred sample A over the other two samples Sample B was the second most preferred with 41.8% of participants reporting that sample B was the preferred flavor. Sample C received the lowest overall acceptability rating, with 73% of the participants disliking the flavor. A majority of participants (51%) stated that sample A was most similar to traditionally prepared non vegan ice cream, and 78% of participants stated that they would consume these ice cream samples outside of the study.

Conclusions: Results support the conclusion that there are acceptable vegan ice cream fat substitutes, if made with coconut cream or cashews. Specifically, 53% of participants stated that they preferred sample A, made with cashew, coconut, coffee, likely because of its rich flavor and creamy texture. Additionally, sample B, produced with dates and coconut cream, also was rated positively. This is supported by the significant correlation between overall acceptability, flavor, and texture of samples A and B. Unlike the first two, sample C, made with coconut milk, was

disliked by 73% of participants. This sample had too much crystallization, making it an unacceptable product.

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CHAPTER I

INTRODUCTION

Observation of popular trends in the food industry has revealed a surge of consumer interest in many naturalistic diets (1). Such diets include the Paleo® diet, vegetarianism, and veganism. In the search for a sustainable way to better their eating habits, consumers turn to these diets, more increasingly the vegan diet (1). Many associate this animal-product free diet with overall health benefits and weight loss. This is because the vegan diet is limited to plant-based foods, and thus it increases the quantity of fruits, vegetables, whole grains, legumes, nuts, and seeds consumed, leading to strongly appealing health benefits.

However, as veganism grows in popularity, a need for adequate substitutes for animal-based ingredients in cooking increases proportionally. This pressing need can only be adequately satisfied if substitutes have equally appealing sensory qualities as their animal-based counterparts, making this need all the more pressing for vegan diet advocates and food companies. Such a need has been identified for one of America's favorite and most widely consumed desserts, ice cream. Ice cream characteristics, such as creaminess, sweetness, and eye-catching appearance, can be directly attributed to its animal-based ingredients, such as milk and cream, that provide fat. However, as consumption of such ingredients is prohibited in the vegan diet, alternative sources of fat must be investigated to find an acceptable plant-based substitute.

The purpose of this research project was to investigate commonly-used vegan ingredient substitutes in ice creams. Qualities such as flavor, sweetness, mouthfeel, eye appeal, color, and overall rating of vegan ingredient substitutions were evaluated for sensory appeal in three different recipe preparations. Following taste tests by University students, their responses and evaluations of these vegan substitutions were measured to identify which ingredients served as

the best ingredient replacements. The null hypothesis was that coconut milk would be shown to be more acceptable as a fat replacer in vegan ice cream than soy milk or almond milk when evaluated based on flavor, sweetness, texture, mouthfeel, eye appeal, color, and overall rating.

CHAPTER II

LITERATURE REVIEW

Veganism and Associated Impact on Health

A vegan diet can essentially be defined as one that avoids the consumption and/or use of meat, fish, poultry or any animal-derived product. Under the same definition, dairy and egg-containing product use is limited to once per month, or less. Main dietary components that are associated with veganism include greater intake of fruits, vegetables, whole grains, and soy, as well as a decreased intake of dietary cholesterol and fat (1). Due to the strict regime of a vegan-approved diet, various health benefits may prove relevant as a result. Research has confirmed that nearly half of the studied vegan population has reported following a strict vegan diet for reasons related to health beliefs (2). Another large fraction of respondents reports reasons for practicing veganism are attributed to animal welfare (1).

The components of the vegan diet, such as fruits, vegetables, and legumes, provide beneficial nutritional components, including dietary fiber, magnesium, vitamin A, vitamin E, iron, and phytochemicals. Vegans generally exhibit a lower serum cholesterol level, body mass index, blood pressure, and risk of heart disease than meat eaters (2). Another consequential effect of increased consumption of fruits and vegetables includes less incidence of stroke and heart disease. In addition, these plant-based foods deliver strong antioxidants and phytochemicals that interfere with and prevent processes associated with cancer development (2). Finally, high consumption of soy products, often a characteristic of the vegan diet, has been shown to positively impact bone health in older women (2).

Despite the myriad of health benefits associated with the vegan diet, there are also increased risks of vitamin and mineral deficiencies. The most prevalent deficiencies include

vitamin D, iron, vitamin B12, zinc, and omega-3 polyunsaturated fats. This is because the most readily available sources of these nutrients are from animal products. Thus, in order to be truly beneficial, a vegan diet must be well-planned, highly varied and often times supplemented (2).

Vegan Fat Substitutions

It is important to use fat substitutes in vegan products that strictly abide by the criteria the vegan population report important to their beliefs. For example, any dairy- and/or egg-containing replacements must be excluded. Soybeans contain a considerable source of fat, allowing them to be an acceptable substitute for dairy solids in the ice cream manufacturing process (3). Low-fat coconut milk consists of a neutral base taste that can impart the flavor of whichever aromatic chosen (4). Coconut oil has similar findings. Therefore, these particular alternatives can serve as vegan-approved fat replacements.

Ice cream is a product composed mainly of the following ingredients: cream, milk solids, sugar and water (5). Differing the ratios of these main components or substituting them will alter the structure of the ice cream itself. A general ice cream formulation contains 7-15% fat, 4-5% milk protein, 5-7% lactose, 12-16% sugars, .5% stabilizers/emulsifiers/flavor, 28-40% total solids, and 60-72% water (6). In ice cream formulations, substitutions of milk fat using a vegetable fat is a technique that is utilized often in the United Kingdom, Asia, and Latin America. (7). When choosing a fat replacer, it is important to keep the structural components similar to milk fat. Fat replacers are generally protein-, carbohydrate-, or lipid-based (7).

The crystallization process of the fat molecules is what contributes to the creamy texture of ice cream. Thus, fat-free or low-fat ice creams are frozen more quickly and at a lower temperature to create smaller ice crystals, which contribute to a smooth and creamy texture. The larger the ice crystals, the less creamy the texture of the ice cream becomes (5). To account for

the removal or reduction of traditional fat, a stabilizer must be included to reproduce a sense of creaminess in vegan ice cream (4). An example of a stabilizer commonly used in vegan ice creams with fat replacements is xanthan gum. This polysaccharide serves as a thickening agent due to its strong ability to keep emulsions dispersed. In addition, it has a neutral flavor and is unaffected by heat and pH, making it a useful ingredient in vegan ice creams (8).

Proper Sensory Evaluation Techniques

In this study, vegan ice cream samples were presented to participants in a blind study. According to Meilgaard, author of Sensory Evaluation Techniques, effectively conducting such a study requires certain techniques and protocol (9). The "bias and sensitivity" of the test subjects must be considered in the screening for subjects. It is vital to elect subjects who will minimize bias and produce reproducible results. Biases to consider in taste tests are those such as food preferences or dietary restrictions. In drafting the procedure of the test, it is also vital to note the close relationship between all senses when sampling. Qualities such as texture, odor, and appearance will influence the opinions of test subjects (9). In addition, according to a study published in the *Journal of Food Science*, the "triangular test", or "odd sample method", is best for conducting a taste test that compares two similar products. The test includes one product that is different and two similar products. Thus, when conducting a sensory test for vegan ice cream, it is most effective to utilize three total samples: two vegan ice creams and one standard icce cream formulation. This ultimately allows for results that reveal obvious trends in preference (10).

CHAPTER III

METHODS

Study Design

This study was a single-blind, cross-sectional design. There was one experimental sensory evaluation session to complete assessment of the utilized fat replacements. The sensory evaluations occurred in the Annie Richardson Bass Building kitchens, following fresh preparation of vegan ice creams to test. The following sensory attributes were assessed: flavor, sweetness, texture, mouthfeel, eye appeal, color, and overall rating of vegan ingredient substitutions for ice cream recipes.

Participants

The participant population included university students, male and female, enrolled in one or more Nutritional Sciences (NTDT) courses. Exclusion criteria included a food allergy to any of the following recipe ingredients: soy, almonds, cashews, coconut, cocoa/chocolate, dates, coffee, or bananas. The number of planned participants was approximately 70 students.

Protocol

The researchers began the study by investigating vegan fat substitutes that are widely accepted and provided adequate mouth feel. Researchers tested various recipes with differing fat replacements until three unique recipes were chosen. A literature review was conducted to ascertain the most effective evaluation scale for sensory testing in order to create an acceptable means of data collection.

Participants were recruited from NTDT classes and by word of mouth. Students signed a consent form before participating in the study. The ice cream samples were placed on the table in front of participants in plastic custard cups, labeled “A, B and C.” The participants were

provided with a copy of the sensory test survey in order to record their level of acceptance of the ice cream sample. A scale of 1-9 was utilized for flavor, sweetness, texture, mouthfeel, eye appeal, color, and overall rating. Surveys were collected, recorded, and analyzed.

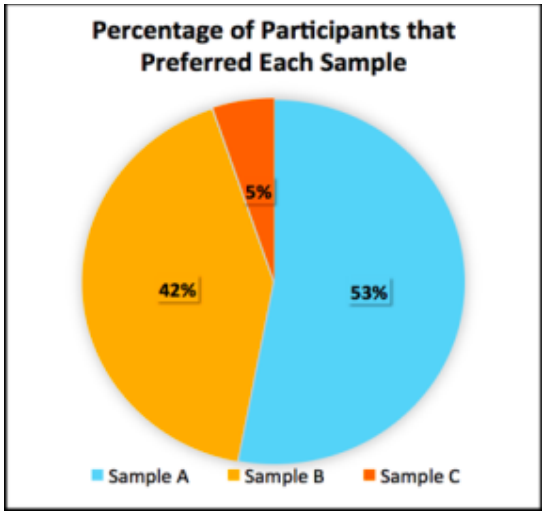
Statistical Analyses

Data was analyzed to meet study objectives. Analyses assessed students' demographics and individual ice cream preferences. Ice cream sample preferences of students were gathered based on the following ice cream sample sensory qualities: flavor, sweetness, texture, mouthfeel, eye appeal, color, and overall rating. Data was organized to determine response frequencies, descriptive statistics, and correlations between relevant variables ($p \leq 0.05$).

CHAPTER IV

RESULTS

The majority of the 54 participants were Science and Engineering majors (60%), and 20% identified as Nursing/Health Science majors. Females comprised 80% of participants. Eighty-three percent (83%) of students said they did not follow a specific diet, 3.6% said they followed a lacto-ovo vegetarian, vegan, or pesco-vegetarian diet. Approximately half of participants were between 20-21 years old (49%). A majority of participants stated they ate ice cream three or more times a month (61.8%). Based on the analysis of the results from the sensory test, a graphic was formulated indicating the percentage of participants that preferred each sample overall.



Specifically, 73% of the participants disliked the flavor of Sample C. A majority of participants (51%) stated that sample A was most similar to traditionally prepared non-vegan ice cream, and 78% of participants stated that they would consume these ice cream samples outside of the study.

Sensory Evaluation Ratings for the 54 Participants who Tasted Sample A

Characteristic	Like	Dislike
Flavor	80%	20%
Texture	52%	48%
Eye Appeal	46%	54%
Color	75%	25%
Overall Acceptability	69%	31%

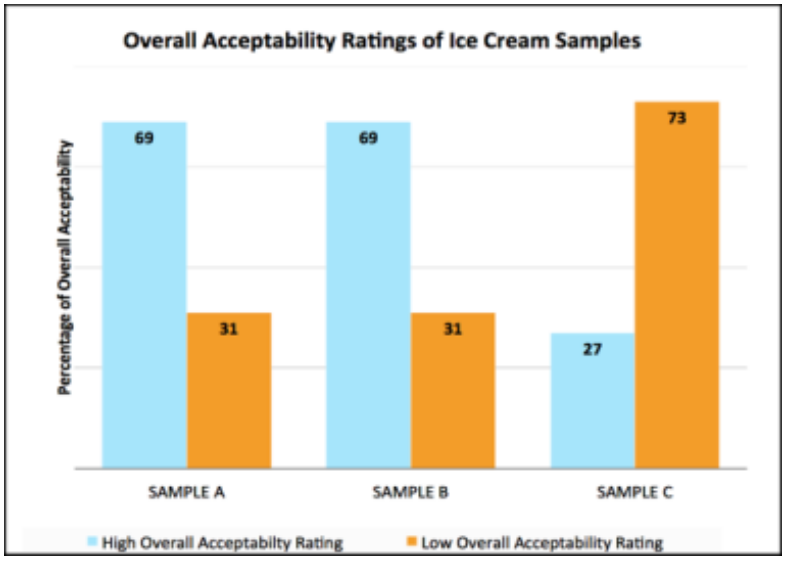
Sensory Evaluation Ratings for the 54 Participants who Tasted Sample B

Characteristic	Like	Dislike
Flavor	67%	33%
Texture	56%	44%
Eye Appeal	69%	31%
Color	78%	22%
Overall Acceptability	69%	31%

Sensory Evaluation Ratings for the 54 Participants who Tasted Sample C

Characteristic	Like	Dislike
Flavor	24%	76%
Texture	13%	87%
Eye Appeal	34%	66%
Color	57%	43%
Overall Acceptability	27%	73%

The graph below visually displays these acceptability ratings.



Furthermore, several correlations between the sensory evaluation results of the different characteristics were measured and resulted in significances worth discussing (greater than .05 correlation). Specifically, those who rated positively/negatively for the flavor of Sample A rated similarly for overall acceptability (.418 correlation). The same is true for texture (.466 correlation) and eye appeal (.334 correlation). Additionally, those who rated Sample A positively/negatively overall generally rated similarly overall for Sample B. However, those who rated eye appeal of Sample B positively/negatively rated eye appeal of Sample A in the opposite manner (-.286 correlation). A positive correlation existed between the overall rating of Sample B and the flavor rating of Sample B (.756). The same is true for the overall rating of Sample B and texture rating of Sample B (.691). In addition, a positive correlation was present between the results for "how often do you eat ice cream?" and the texture rating of Sample B (.316). Based on observation of results, those who ranked Sample A as most liked flavor gave flavor C a low score; this was emphasized by a .303 correlation.

CHAPTER V

DISCUSSION AND CONCLUSION

This sensory test shows that there are acceptable vegan ice cream fat substitutes. Specifically, sample A, made with cashew, coconut, coffee, was the most widely liked ice cream among participants. Fifty-three percent (53%) of participants stated that they preferred Sample A, likely because of its rich flavor and creamy texture. Sample A was also chosen by 51% of participants as the most similar to traditional ice cream. However, Sample B, produced with dates and coconut cream, also was received positively. Results show that the texture, eye appeal, and color of Sample B were given higher ratings than those of Sample A. These characteristics created a product similar to traditional ice cream, making Sample B another acceptable replacement. This is further supported by the significant correlation between overall acceptability of Samples A and B. Unlike the first two samples, Sample C, made with coconut milk and regular sugar, had a low overall acceptability ranking, with 73% of participants stating that they disliked the sample. This sample, when compared to the other two, had more crystallization and poor mouth feel, making it an unacceptable product. Thus, to conclude, recipes utilizing cashews and coconut cream as vegan ice cream fat replacements tend to produce products with good mouthfeel, texture, and flavor, like that of regular ice cream.

REFERENCES

1. Dyett PA, Sabaté J, Haddad E, Rajaram S, Shavlik D. Vegan lifestyle behaviors. An exploration of congruence with health-related beliefs and assessed health indices. Appetite. 2013;67:119-124. http://www.sciencedirect.com.ezproxy.tcu.edu/science/article/pii/s0195666313001281. Accessed October 18, 2016.

2. Craig WJ. Health effects of vegan diets - American Society for Nutrition. http://ajcn.nutrition.org/content/89/5/1627s.short. Accessed October 21, 2016.

3. Sutar N, Sutar PP, Singh G. Evaluation of different soybean varieties for manufacture of soy ice cream. International Journal of Dairy Technology. 2010;63(1):136-142. http://eds.a.ebscohost.com.ezproxy.tcu.edu/ehost/pdfviewer/pdfviewer?sid=16fa3b86-869a-4c00-aa8b-6994f962baa4@sessionmgr4008&vid=1&hid=4203. Accessed October 18, 2016.

4. Clarke C. The Science of Ice Cream. Cambridge: The Royal Society of Chemistry; 2012. https://books.google.com/books?hl=en&lr=&id=zd10dzil2lac&oi=fnd&pg=pr15&dq=ice cream&ots=avaq-8dncn&sig=qgwjmm7w0yuxqjwyswgoo6eofcs#v=onepage&q=ice cream&f=false. Accessed October 18, 2016.

5. Warren M. Science Behind Ice Cream Revealed. IFT. http://www.ift.org/knowledge-center/learn-about-food-science/food-facts/science-behind-icecream.aspx. Accessed September 18, 2016.

6. Clark M. Vegan Ice Cream From 'Van Leeuwen Artisan Ice Cream' - The ... The New York Times. http://www.nytimes.com/2015/07/22/dining/cookbook-review-van-leeuwen-artisan-ice-cream-by-ben-van-leeuwen.html. Published July 17, 2015. Accessed October 20, 2016.

7. Marshall RT. Ice Cream. 6th ed. New York: Kluwer Academic/Plenum Publishers; 2003. https://books.google.com/books?hl=en&lr=&id=rp7sbwaaqbaj&oi=fnd&pg=pa55&dq=ice cream fat replacer&ots=a8qgexm3pr&sig=p4rce9dhguomcgnu9xdzb7yeygs#v=onepage&q=ice cream fat replacer&f=false. Accessed October 18, 2016.

8. Naresh L, Shailaja M. Stabilizer Blends and their importance in Ice cream Industry – A Review . New Zealand Food Magazine. 2006. http://www.taiyolucid.com/pdf/1467227096_stabilizer.pdf. Accessed February 20, 2017.

9. Meilgaard M, Civille GV, Carr BT. Sensory Evaluation Techniques. Boca Raton: CRC Press; 1991.

10. Roessler EB, Warren J, Guymon JF. Significance of Triangular Taste Tests. Journal of Food Science. June 2008.

Appendix A

National Institutes of Health Certificates

Certificate of Completion

The National Institutes of Health (NIH) Office of Extramural Research certifies that **Maria Martinez** successfully completed the NIH Web-based training course "Protecting Human Research Participants".

Date of completion: 03/01/2017.

Certification Number: 2340484.

Certificate of Completion

The National Institutes of Health (NIH) Office of Extramural Research certifies that **Chandler Bourff** successfully completed the NIH Web-based training course "Protecting Human Research Participants".

Date of completion: 09/18/2016.

Certification Number: 2178588.

Appendix B

Evidence Analysis Library Certificates

CPE Accredited Provider
Commission on Dietetic Registration
the credentialing agency for the Academy of Nutrition and Dietetics

Continuing Professional Education Certificate of Attendance
-Attendee Copy-

Participant Name: Maria Martinez

RD/RDN/DTR Number:

Session Title: Evidence Analysis Library Tutorial

CDR Activity Number: 110257

Date Completed: 08/31/16 CPEUs Awarded: 1.0

Learning Need Code: CPE Level: 2

Diane Moore Enos, MPH, RD

Provider Signature

PROVIDER #: AM003

RETAIN ORIGINAL COPY FOR YOUR RECORDS

**Refer to your Professional Development Portfolio Learning Needs Assessment Form (Step 2)*

CPE Accredited Provider
Commission on Dietetic Registration
the credentialing agency for the Academy of Nutrition and Dietetics

Continuing Professional Education Certificate of Attendance
-Attendee Copy-

Participant Name: Chandler Bourff

RD/RDN/DTR Number:

Session Title: Evidence Analysis Library Tutorial

CDR Activity Number: 110257

Date Completed: 08/28/16 CPEUs Awarded: 1.0

Learning Need Code: CPE Level: 2

Diane Moore Enos, MPH, RD

Provider Signature

PROVIDER #: AM003

RETAIN ORIGINAL COPY FOR YOUR RECORDS

**Refer to your Professional Development Portfolio Learning Needs Assessment Form (Step 2)*

Appendix C

INSTITUTIONAL REVIEW BOARD
STUDENT PROTOCOL REVIEW REQUEST

The TCU Institutional Review Board (IRB) is responsible for protecting the welfare and rights of the individuals who are participants of any research conducted by faculty, staff, or students at TCU. Approval by the IRB must be obtained prior to initiation of a project, whether conducted on-campus or off-campus. While student research is encouraged at both the undergraduate and graduate level, only TCU faculty or staff may serve as Principal Investigator and submit a protocol for review.

Please submit this protocol to the appropriate Departmental Review Board for recommendation and submission to the IRB. DRBs will submit to the IRB electronically at IRB.StudentSubmit (pdf preferred). Include the Protocol Approval Form as a word document with highlighted sections filled in. Also submit a consent document, HIPAA form if applicable, Protecting Human Research Participants Training certificates, recruitment materials, and any questionnaires or other documents to be utilized in data collection. A template for the consent document and HIPAA form, instructions on how to complete the consent, and a web link for the Protecting Human Research Participants Training are available on the TCU IRB webpage at www.research.tcu.edu. Submission deadline for protocols is the 15th of the month prior to the IRB Committee meeting.

1. Date: April 10, 2017

2. Study Title: Sensory Acceptability of Vegan Ingredient Substitutions in Ice Cream

3. Principal Investigator (must be a TCU faculty or staff): Anne VanBeber, PhD, RD, LD

4. Department: Nutritional Sciences

5. Other Investigators: List all faculty, staff, and students conducting the study including those not affiliated with TCU.

Nicholle Benedict and Chandler Bourff, juniors - Coordinated Program in Dietetics; Maria Martinez, junior – Didactic Program in Dietetics

6. Project Period: September 2016-April 2018

7. If you *have* external funding for this project –
Funding Agency: N/A **Project #:** N/A **Date for Funding:** N/A

8. If you *intend to seek/are seeking* external funding for this project –

Funding Agency: N/A **Amount Requested From Funding Agency:** N/A

Due Date for Funding Proposal: N/A

9. Purpose: Describe the objectives and hypotheses of the study and what you expect to learn or demonstrate:

Because of the growing popularity of vegan diets, this research project will study the flavor, sweetness, mouthfeel, eye appeal, color, and overall rating of vegan ingredient substitutions for ice cream recipes. The purpose of this study is to measure college students' responses and evaluations of these vegan substitutions, and to identify which ingredients serve as the best ingredient replacements.

10. Background: Describe the theory or data supporting the objectives of the study and include a bibliography of key references as applicable.

A vegan diet can essentially be defined as one that avoids the consumption and/or use of meat, fish, poultry or any animal-derived product. Under the same definition, dairy and egg-containing product use is limited to once per month, or less. Main dietary components that are associated with veganism include greater intake of produce, whole grains, and soy, as well as a decreased intake of cholesterol and fat (1). Due to the strict regime of a vegan-approved diet, various health benefits may prove relevant as a result. Research has confirmed that nearly half of the studied vegan population have reported following a strict vegan diet for reasons related to health beliefs. Another large fraction of respondents report reasons for practicing veganism are attributed to animal welfare (1).

Vegans generally exhibit a lower serum cholesterol level, body mass index, blood pressure, and risk of heart disease than meat eaters (2). The components of the vegan diet, such as fruits, vegetables, and legumes, provide beneficial nutritional components. Some of these components include dietary fiber, magnesium, several vitamins, iron, and phytochemicals, among others. Because the vegan diet excludes all animal products, fruits and vegetables are generally consumed in greater quantity. This is beneficial because they provide nutrients that are associated with lower blood cholesterol, and as a result, less incidences of stroke and heart disease. In addition, these plant-based foods deliver strong antioxidants and phytochemicals that interfere with and prevent processes associated with cancer development (2). Finally, high consumption of soy products, as is often the case in the vegan diet, has been shown to positively impact bone health in older women (2).

Despite the health benefits associated with the vegan diet, there are also increased risks of vitamin and mineral deficiencies. The most prevalent deficiencies include vitamin D, iron, vitamin B12, zinc, and omega-3 polyunsaturated fats. This is because the most readily available sources of these nutrients are animal products. Thus, in order to be truly beneficial, a vegan diet must be well-planned, highly varied, and in some cases, supplemented (2).

It is important to use fat substitutions in vegan products that strictly abide by the criteria the vegan population report important to their beliefs. For example, any dairy- and/or egg-containing potential replacements must be excluded. Soybeans contain a considerable source of fat, allowing them to be a great substitute for dairy solids in the ice cream manufacturing process

(3). Low-fat coconut milk consists of a neutral base taste that can take on the flavor of whichever aromatic chosen (4). Coconut oil has similar findings. Therefore, these particular alternatives can also serve as a vegan-approved fat replacement.

Ice cream is a product composed mainly of the following ingredients: cream, milk solids, sugar and water (5). Differing the ratios of these main components or substituting them will alter the structure of the ice cream itself. A general ice cream formulation is as follows: fat (7-15%), milk protein (4-5%), lactose (5-7%), sugars (12-16%), stabilizers/emulsifiers/flavor (0.5%), total solids (28-40%), and water (60-72%) (6). In ice cream formulations, substitutions of milk fat using a vegetable fat is a technique that is utilized often in the United Kingdom, Asia, and Latin America. (7). When choosing a fat replacer, it is important to keep the structural components similar to milk fat. Fat replacers are generally protein-, carbohydrate-, or lipid-based (7).

The crystallization process of the fat molecules is what contributes to the creamy texture of ice cream. Thus, fat-free or low-fat ice creams are frozen more quickly and at a lower temperature to create smaller ice crystals. The larger the ice crystals, the less creamy the texture of the ice cream becomes (5). To account for the removal or reduction of traditional fat, a stabilizer must be included to reproduce a sense of creaminess in vegan ice cream (4). An example of a stabilizer commonly used in ice creams with fat replacements is xanthan gum. This polysaccharide acts as a thickening agent due to its strong ability to keep emulsions dispersed. In addition, it has a neutral flavor and is unaffected by heat and pH, making it a useful ingredient in vegan ice creams (8).

In this study, vegan ice cream samples will be presented to participants in a blind study. According to Meilgaard, author of Sensory Evaluation Techniques, effectively conducting such a study requires certain techniques and protocol (9). The “bias and sensitivity” of the test subjects must be considered in the screening for subjects. It is vital to elect subjects who will minimize bias and produce reproducible results. Biases to consider in taste tests are those such as food preferences or dietary restrictions. In drafting the procedure of the test, it is also vital to note the close relationship between all senses when sampling. Qualities such as texture, odor, and appearance will influence the opinions of test subjects (9). In addition, according to a study published in the *Journal of Food Science*, the “triangular test”, or “odd sample method”, is best for conducting a taste test that compares two similar products. The test includes one product that is different and the two similar products. Thus, when conducting a sensory test for vegan ice cream, it is most effective to utilize three total samples: two vegan and one regular. This ultimately allows for results that reveal obvious trends in preference (10).

References

1. Dyett PA, Sabaté J, Haddad E, Rajaram S, Shavlik D. Vegan lifestyle behaviors. An exploration of congruence with health-related beliefs and assessed health indices. Appetite. 2013;67:119-124. http://www.sciencedirect.com.ezproxy.tcu.edu/science/article/pii/s0195666313001281. Accessed October 18, 2016.

2. Craig WJ. Health effects of vegan diets - American Society for Nutrition. http://ajcn.nutrition.org/content/89/5/1627s.short. Accessed October 21, 2016.

3. Sutar N, Sutar PP, Singh G. Evaluation of different soybean varieties for manufacture of soy ice cream. International Journal of Dairy Technology. 2010;63(1):136-142. http://eds.a.ebscohost.com.ezproxy.tcu.edu/ehost/pdfviewer/pdfviewer?sid=16fa3b86-869a-4c00-aa8b-6994f962baa4@sessionmgr4008&vid=1&hid=4203. Accessed October 18, 2016.

4. Clarke C. The Science of Ice Cream. Cambridge: The Royal Society of Chemistry; 2012. https://books.google.com/books?hl=en&lr=&id=zd10dzil2lac&oi=fnd&pg=pr15&dq=ice cream&ots=avaq-8dncn&sig=qgwjmm7w0yuxqjwyswgoo6eofcs#v=onepage&q=ice cream&f=false. Accessed October 18, 2016.

5. Warren M. Science Behind Ice Cream Revealed. IFT. http://www.ift.org/knowledge-center/learn-about-food-science/food-facts/science-behind-icecream.aspx. Accessed September 18, 2016.

6. Clark M. Vegan Ice Cream From 'Van Leeuwen Artisan Ice Cream' - The ... The New York Times. http://www.nytimes.com/2015/07/22/dining/cookbook-review-van-leeuwen-artisan-ice-cream-by-ben-van-leeuwen.html. Published July 17, 2015. Accessed October 20, 2016.

7. Marshall RT. Ice Cream. 6th ed. New York: Kluwer Academic/Plenum Publishers; 2003. https://books.google.com/books?hl=en&lr=&id=rp7sbwaaqbaj&oi=fnd&pg=pa55&dq=ice cream fat replacer&ots=a8qgexm3pr&sig=p4rce9dhguomcgnu9xdzb7yeygs#v=onepage&q=ice cream fat replacer&f=false. Accessed October 18, 2016.

8. Naresh L, Shailaja M. Stabilizer Blends and their importance in Ice cream Industry – A Review . *New Zealand Food Magazine*. 2006. http://www.taiyolucid.com/pdf/1467227096_stabilizer.pdf. Accessed February 20, 2017.

9. Meilgaard M, Civille GV, Carr BT. Sensory Evaluation Techniques. Boca Raton: CRC Press; 1991.

10. Roessler EB, Warren J, Guymon JF. Significance of Triangular Taste Tests. Journal of Food Science. June 2008.

11. <u>Subject Population:</u> Describe the characteristics of the participant population including the inclusion and exclusion criteria and the number of participants you plan to recruit:
The participant population will consist of university students, male and female, enrolled in one or more Nutritional Sciences (NTDT) courses. Individuals cannot participate in the study if they have a food allergy to any of the following ingredients: soy, almonds, cashews, coconut, cocoa/chocolate, dates, coffee, or bananas. The number of planned participants is approximately 70 students.

12. <u>Recruitment Procedure:</u> Describe your recruitment strategies including how the potential participants will be approached and precautions that will be taken to minimize the possibility of undue influence or coercion. Include copies of the recruitment letters, leaflets, etc. in your submission.
Participants will be recruited by the researchers via emails sent through the TCU Student Nutrition and Dietetics Association, word of mouth, and through participation requests in NTDT classes. Flyers will also be posted throughout the Nutritional Sciences building. Researchers will emphasize that participation is voluntary.

13. <u>Consenting Procedure:</u> Describe the consenting procedure, whether participation is completely voluntary, whether the participants can withdraw at any time without penalty, the procedures for withdrawing, and whether an incentive (describe it) will be offered for participation. If students are used as participants, indicate an alternative in lieu of participation if course credit is provided for participation. If a vulnerable population is recruited, describe the measures that will be taken to obtain surrogate consent (e.g., cognitively impaired participants) or assent from minors and permission from parents of minors.
A consent form will be read and agreed upon before participating in the sensory taste test. Participation is completely voluntary, and participants can withdraw at any time without penalty, and there is no incentive offer. Course credit is not given to students if they decide to participate in this study.

14. <u>Study Procedures:</u> Provide a chronological description of the procedures, tests, and interventions that will be implemented during the course of the study. Indicate the number of visits, length of each visit, and the time it would take to undergo the various tests, procedures, and interventions. If blood or tissue is to be collected, indicate exactly how much in simple terms. Flow diagrams may be used to clarify complex projects.
The researchers will begin the study by investigating vegan fat substitutes that are widely accepted, providing adequate mouth feel, to be used in the production of vegan ice creams. Researchers will find and test various recipes with differing fat replacements until three unique recipes are chosen. Literature reviews will be conducted to ascertain what the most effective sensory scale is for sensory testing in order to create an acceptable means of data collection. Next, participants will be recruited from NTDT classes and by word of mouth. A maximum of four participants will be allowed in the testing environment at all times and will be separated by physical dividers. The ice cream samples will be placed on the table in front of participants in plastic custard cups, labeled "A, B and C." The participants will also be handed a copy of the sensory test survey in order to record their level of acceptance of the ice cream sample on a scale

of 1-9 for flavor, sweetness, mouthfeel, eye appeal, color, and overall rating. Surveys will be collected, recorded, and analyzed. There will be a minimum of 13 rounds, each participant paying 1 visit. The maximum participation time per round will be 5 minutes. Research report will be drafted, revised, and published.

15. Data Analyses: Describe how you will analyze your data to answer the study question.
Data will be analyzed to meet study objectives. Analyses will assess students' demographics and individual ice cream preferences. And preference of individual samples of vegan ice creams based on flavor, sweetness, mouthfeel, eye appeal, color, and overall rating. Data will be organized to determine response frequencies, descriptive statistics, and correlations between relevant variables ($p \leq 0.05$).

16. Potential Risks and Precautions to Reduce Risk: Indicate any physical, psychological, social, or privacy risk which the subject may incur. Risk(s) must be specified. Also describe what measures have been or will be taken to prevent and minimize each of the risks identified. If any deception is to be used, describe it in detail and the plans for debriefing.
Extreme dissatisfaction of the test product may serve as a discomfort. Accidental participation in the study by a participant with food allergies may exist as a potential risk. Participants will be asked to list their foods allergies, food safety procedures will be strictly followed, and disclosure of the type of food being tested will occur when recruiting participants.

17. Procedures to Maintain Confidentiality: Describe how the data will be collected, de-identified, stored, used, and disposed to protect confidentiality. If protected health information is to be re-identified at a later date, describe the procedure for doing so. All signed consents and hard data must be stored for a minimum of 3 years in a locked filing cabinet (and locked room) in the principal investigator's office, lab, or storage closet at TCU. Your professional society may recommend keeping the materials for a longer period of time.
A 9-point sensory scale will be administered to students who choose to take part in the research. Questions will address flavor, sweetness, mouthfeel, eye appeal, color and overall rating of the product being test. Comments are optional. Participants will be asked to complete the printed survey following consent and tasting. Survey completion should take 5 minutes, and participation is completely voluntary. Participants can withdraw at any time without penalty. Survey data will be collected, de-identified, stored, used, and disposed of to protect confidentiality. All signed consents and hard data will be stored for a minimum of three years in a locked filing cabinet (and locked room) in the principal investigator's office at TCU.

18. Potential Benefits: Describe the potential benefits of the research to the participants, to others with similar problems, and to society.
Participants will be granted the opportunity to sample healthier alternatives to conventional ice cream. They will be given a chance to sample new and unique flavors through the chosen vegan recipes that they may not have otherwise been exposed to.

19. Training for Protecting Human Research Participants: Submit training certificates for all the study investigators. The training link is available on the TCU IRB webpage at www.research.tcu.edu.

20. Check List for the Items That Need to be Submitted: Please combine all the files into one pdf document before submitting the materials electronically to the IRB. To prevent any delay in the approval of your protocol, use the most recent template for the protocol, consent document, and HIPAA form by downloading them from www.research.tcu.edu each time you prepare your materials.

a. Protocol
b. Consent document
c. HIPAA form if applicable
d. Protecting Human Research Participants Training certificate for each investigator
e. Recruitment fliers, letters, ads, etc.
f. Questionnaires or other documents utilized in screening and data collection

Appendix D

Consent Form

Texas Christian University
Fort Worth, Texas

Participant#_____

CONSENT TO PARTICIPATE IN RESEARCH

Title of Research: Sensory Acceptability of Vegan Ingredient Substitutions in Ice Cream

Funding Agency/Sponsor: N/A

Study Investigators: Nicholle Benedict and Chandler Bourff, Seniors - Coordinated Program in Dietetics; Maria Martinez, Senior - Didactic Program in Dietetics; Dr. Anne VanBeber, Professor and Chair, Department of Nutritional Sciences

What is the purpose of the research? Because of the growing popularity of vegan diets, this research project studies the flavor, sweetness, mouthfeel, color, eye appeal, and overall rating of vegan ingredient substitutions for ice cream. The purpose of this study is to measure the university students' reactions and ratings of these substitutions and to identify which ingredients serve as the best ingredient replacements.

How many people will participate in this study? The participant population will consist of university students, male and female, enrolled in one or more Nutritional Sciences (NTDT) courses. Individuals cannot participate in the study if they have a food allergy to any of the following ingredients: soy, almonds, cashews, coconut, cocoa/chocolate, dates, coffee, or bananas. The number of planned participants is approximately 70 students.

What is my involvement for participating in this study? Involvement consists of taste testing homemade vegan ice cream and reporting level of acceptability.

How long am I expected to be in this study for and how much of my time is required? Participants will be expected to plan for 5-10 minutes of total involvement time.

What are the risks of participating in this study and how will they be minimized? Extreme dissatisfaction of the test product may serve as a discomfort. Accidental participation in the study by a participant with food allergies may exist as a potential risk. Participants will be asked

to list their foods allergies, food safety procedures will be strictly followed, and disclosure of the type of food being tested will occur when recruiting participants.

What procedures will take place in protection of participants with food allergies? Participants will be asked to list their foods allergies and if any of the listed allergies are utilized in the making of the ice cream samples, researchers will inform the participant they are not eligible to participate. Individuals cannot participate in the study if they have a food allergy to any of the following ingredients: soy, almonds, cashews, coconut, cocoa/chocolate, dates, coffee, or bananas.

What are the benefits for participating in this study? Participants will be granted the opportunity to sample healthier alternatives to conventional ice cream. They will be given a chance to sample new and unique flavors through the chosen vegan recipes that they may not have otherwise been exposed to.
Will I be compensated for participating in this study? No compensation will be provided for participation.

What is an alternate procedure(s) that I can choose instead of participating in this study? There is not an alternate procedure offered for participation in this study.

How will my confidentiality be protected? Survey data will be collected, de-identified, stored, used, and disposed of to protect confidentiality. All signed consents and hard data will be stored for a minimum of 3 years in a locked filing cabinet (and locked room) in the principal investigator's office at TCU.

Is my participation voluntary? Participation is completely voluntary. Participants can withdraw at any time without penalty.

Can I stop taking part in this research? Yes, participants are able to withdraw from the study at any time.

What are the procedures for withdrawal? Participants are asked to inform one of the researchers present that participation in the study is no longer desired.

Will I be given a copy of the consent document to keep? Yes, all participants will be given a copy of the consent document to keep.

Who should I contact if I have questions regarding the study? Participants are instructed to contact Dr. Anne VanBeber (a.vanbeber@tcu.edu), Nicholle Benedict (n.benedict@tcu.edu), Chandler Bourff (c.bourff@tcu.edu), or Maria Martinez (maria.martinez@tcu.edu) with questions regarding the study.

Who should I contact if I have concerns regarding my rights as a study participant?

Dr. Dennis Cheek, Chair, TCU Institutional Review Board, 817 257-6741.
Dr. Tim Barth, Co-Chair, TCU Institutional Review Board, 817 257-6427.

Dr. Bonnie Melhart, TCU Research Integrity Office, Telephone 817-257-7104.

Your signature below indicates that you have read or been read the information provided above, you have received answers to all of your questions and have been told who to call if you have any more questions, you have freely decided to participate in this research, and you understand that you are not giving up any of your legal rights.

Your signature also confirms that you are not allergic to any of the following allergens:

Soy	Cocoa/chocolate
Almonds	Dates
Cashews	Coffee
Coconut	Bananas

Participant Name (please print):
_____

Participant Signature:
_____Date:_____

Investigator Name (please print):_____

Investigator Signature:
_____Date:_____

Appendix E

Likert Scale

Acceptability of Vegan Dairy Substitutes in Ice Cream

Directions: Taste each ice cream sample (A, B, C). Rate each sample according to the scale below and circle the corresponding number: 1 being "I dislike extremely" and 9 being "I like extremely". Then, answer the questions below.

FOOD ITEM:	A	B	C
FLAVOR	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
TEXTURE	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
EYE APPEAL	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
COLOR	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
OVERALL RATING	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9

Answer the following questions:

1. **Are you male or female?**

2. **What is your major/minor?**

3. **How old are you?**

4. **Are you vegan or vegetarian? If so, which one?**

5. **Do you eat ice cream at least once a week? If so, how often?**

6. **Would you consume any of these ice creams outside of the study? If so, which sample(s)?**

7. **Overall, which sample did you like the most and why?**

8. **Which sample is most similar to traditionally prepared non-vegan ice cream?**

Appendix F

Recipe A

CREAMIEST VEGAN CHOCOLATE ICE CREAM

Crazy Vegan Kitchen Serves 8
3/4 cup Cashews
1 1/2 cups Water
1/4 teaspoon Xanthan Gum
1/2 teaspoon Instant Espresso
2 Tablespoons Cocoa Powder
1/4 teaspoon Salt
1 teaspoon Vanilla Extract
1 cup Coconut Cream
1/2 cup Coconut Milk
1/2 cup Cane Sugar
6 oz Dark Chocolate (Vegan)
2 Tablespoons Cornstarch

In a blender, combine Cashews, Water, Xanthan Gum, Instant Espresso, Cocoa Powder, Salt, Vanilla Extract, Coconut Cream and Coconut Milk. Blend on high till everything is nice and smooth.
Pour out all of this mixture into a saucepan, leaving 1 cup of it behind.
To the filled saucepan, add Sugar and Dark Chocolate. Stir over low heat until chocolate and sugar have fully melted and mixture is warm.
To the remaining 1 cup of liquid, whisk in Cornstarch till dissolved. Gradually stream this mixture into the saucepan whilst whisking non stop. Once everything has been incorporated, whisk away until the mixture comes to a soft boil. This is to cook out the cornstarch and thicken the mix. But, remember to whisk whisk whisk so no lumps form!
Once it has come to a soft boil, turn heat off and transfer mixture into a bowl or measuring cup. Cover with cling film and make sure to press it against the surface of the mixture so a skin does not form.
Cool to room temperature and then churn in ice cream maker. Alternatively, if you do not have an ice cream maker, follow steps for manual churning mentioned in my post.
Once out of the ice cream maker, place in an airtight ice cream or tupperware box, cover, and freeze to allow it to further firm up.

Recipe B

NO CHURN VEGAN CHOCOLATE ICE CREAM

- 2 14-ounce cans coconut cream *OR* full fat coconut milk, chilled overnight in the fridge
- 2/3 cup unsweetened cocoa or cacao powder powder
- 8 ounces pitted dates (if not sticky and moist, soak in warm water for 10 minutes then drain)
- 1 tsp pure vanilla extract
- 1 ¼ cup unsweetened almond milk

Place a large mixing bowl in the freezer to chill for 10 minutes.
In the meantime, add moist, pitted dates to a food processor and process until small bits remain. Then add hot water a little at a time until it forms a thick paste. Set aside.
Without tipping the cans, scoop out the coconut cream from the cans of coconut cream OR coconut milk, reserving the clear liquid for other uses. Place in chilled mixing bowl.
NOTE: If you're using coconut milk, you'll likely use less sweetener because there's less volume.
Using a mixer, whip until creamy and smooth. Then add cocoa powder, vanilla, almond milk and half of the date paste. Whip until fully incorporated.
Taste and adjust flavors as needed. I ended up adding most of the date paste and a little more cocoa powder.
Transfer to a parchment-lined freezer-safe container and cover loosely with plastic wrap, then foil to help freeze.
You can take this out in a couple of hours for a chilled mousse-like ice cream. Freeze overnight for a firmer ice cream.
Set out for at least 20 minutes prior to scooping, and use a scoop warmed under hot water for a proper scoop.
Will keep in the freezer for up to one week, but best when fresh. Serves 12.

Recipe C

VEGAN CHOCOLATE ICE CREAM

- 1 cup milk of choice or canned coconut milk
- 1 cup canned coconut milk OR nondairy creamer or cashew cream
- 1/4 cup cocoa powder
- 3 T. sugar

Whisk all ingredients (except optional chocolate chips) in a dish. *Ice Cream Maker Version: transfer to your ice cream maker and watch the magic! (It took about 12-14 minutes in my Cuisinart. Make sure your ice cream maker's base is completely frozen before use, or it will NOT work!) Stir in chips. You can eat it straight from the machine, or freeze a few hours for firmer texture. Homemade ice cream is best the day it's made, but you can technically thaw it out and it will keep for a few weeks. *Food Processor/Vitamix Version: Pour your whisked mixture into ice cube trays and freeze. The next day, thaw just enough so your machine can blend the frozen mixture. Then process, scraping down or tampering as needed. *No Machine Version: If you don't you don't have any machine, you can still make a less-creamy (but still delicious) ice milk. Transfer the whisked mixture to a shallow container and freeze. Stir every half hour until you achieve a frozen ice milk texture. Yield: Serves 3-4