Spring 2017

The Protein Flip

An Environmental Analysis of

Beef Substitution at Boston College

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Abstract

The negative environmental impacts of beef are well documented. To minimize these impacts, much of the current literature prescribes changes to production methods. Meanwhile, little attention has been paid to changing consumption patterns. In this study, a beef substitution experiment was administered in Corcoran Commons, a dining hall operated by Boston College Dining Services. In a single blind experiment, four blends of mushroom and beef meatballs were tested. Respondents recorded their evaluations of five gastronomic qualities and data produced was analyzed to determine popularity, variance, and correlation. Results indicated that while the most popular sample was the control 100% beef meatball, the majority of respondents selected a mushroom and beef blend as their top choice. These findings are salient to university dining services seeking to reduce on-campus beef consumption. This study was part of a larger initiative managed by the Menus of Change University Research Collaborative, an interscholastic organization founded by Stanford University and The Culinary Institute of America.

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I. INTRODUCTION

Environmental Background

Livestock-based food production is responsible for more than one fifth of all global greenhouse gas (GHG) emissions, which in turn contribute to climate change (Eshel et al. 2014). Beef production requires 20 times more land and emits 20 times more GHG emissions per unit of edible protein than does the production of plant-based protein sources, such as beans, peas, and lentils (Ranganathan and Waite 2016). The calculation of beef's feed conversion ratio (FCR), a measure of ounce-of-feed required to ounce-of-meat produced,[1] reveals that even compared to other animal-based proteins, beef is an anomaly. While the FCR of chicken is 4.5 and pork is 9.4, the FCR of beef is 25.0 (Smil 2002). In 2016, The Economist estimated that producing one pound of beef is associated with about 1,000 pounds of GHG emissions, whereas producing one pound of pork is associated with 53 pounds and one pound of chicken with only eight pounds ("Why Eating More…"). Eshel et al. also note that on average, beef production uses 11 times as much water as other livestock (Eshel et al. 2014). Robert Glennon supplements this argument, adding that producing one pound of beef requires 2,500 gallons of water (Glennon 2009). Reducing beef consumption, therefore, has the potential to reduce GHG emissions and water use.

The standard American diet is heavily reliant on meat, especially beef. More than 30 million cattle are raised in the U.S. for beef production annually ("Cattle"). With such a reliance, the benefits of shifting food consumption patterns away from beef and toward plant alternatives are not only environmental but individual as well. To wit, if consumers were to eat more plants and less meat, by 2050 GHG emissions could be cut by 66%, up to 8 million climate-vulnerable lives could be saved, and climate change-related damages totaling $1.5 trillion could be avoided

[1] Found by dividing feed required by edible weight.

(Springmann et al). These global-scale environmental findings corroborate medical research which has found that beef consumption is highly correlated with many forms of cancer, type II diabetes, and heart disease (Boada et al, 2016).

There are many ways to minimize beef's negative environmental impacts. Some methods, like prescribed or management intensive grazing, focus on cattle herding. These methods aim to increase the amount of carbon stored in the soil while simultaneously reducing the emission of digestive methane. Other methods, such as increasing operational efficiency, focus on production directly. A number of other methods prioritize transportation, waste, and educational outreach. While many of these methods implicate higher costs for the end-consumer, recent research suggests that less than 25% would be willing to pay that price (Li et al. 2016). Therefore, rather than implement changes at the supplier level, this report focuses on consumers. To this end, it must be acknowledged that a myriad of options for reducing beef consumption exist. Removing beef from one's diet altogether is one option. A less radical option is the subject of this report: reducing beef consumption through partial displacement, otherwise known as meat substitution.

Study Context

The goal of this study was to discern the potential for reducing beef consumption through the displacement of a portion of ground beef with mushrooms in Boston College Dining Services (BCDS) menu items that contain ground beef, such as burgers, chili, meatballs, nachos, quesadillas, and other ethnic foods. This study was part of a larger initiative titled "The Protein Flip," a nationwide effort managed by the Menus of Change University Research Collaborative (MCURC). The MCURC describes its operations and purpose as follows:

> Founded and jointly led by Stanford University and The Culinary Institute of America, the Menus of Change University Research Collaborative (MCURC) is a network of 142 members representing 32 member colleges and universities, 12 colleges and universities represented by academic faculty, and five ex officio member institutions. Members include

> university-based faculty and staff as well as leaders from campus dining operations. The Collaborative consists of a diverse mix of perspectives as far as geographic location, size and type of institution (both private and public), fields of study, and types of dining operations.
> The purpose of MCURC is to create a culture of sharing and innovation within and among colleges and universities using the Menus of Change principles in their campus dining operations, and to develop a research agenda related to those principles. MCURC aims to impact the university and college food system by forming a synergistic network of university-based scholars, administrators, foodservice business leaders, and executive chefs to explore critical food issues within university settings, as well as to share these research findings with colleagues. The interdisciplinary strengths of the collaborative address the critical roles that culinary arts, menu design, ingredient sources, and restaurant layout can play in fostering these changes. ("About Us - Overview").

The MCURC's focus on improving university dining service sustainability is well-grounded. As centers of research and innovation but also of consumption and waste, universities are uniquely situated. Most modern universities serve as microcosmic hubs for everyday life: they provide for students' every need, ranging from laundry services to landscaping and from food preparation to housing. Universities are thus empowered and indeed compelled to make decisions regarding environmental issues usually reserved for government. For instance, whereas clearing an icy road normally falls under the purview of local authorities, on private campuses it is the university's responsibility to ensure safe travel. Often, this task implicates environmental decisions such as what type of ice melt and cleaning vehicles to use. While housing, transportation, landscaping, facilities, and trash management are important factors in overall university sustainability, perhaps there is no more environmentally consequential factor than dining services.

At Boston College, three dining halls operate alongside eight smaller serveries to provide its 14,250 students with "balanced, nutritious, and delicious meals" ("Health and Wellness"). Employing nine managers, 80 full time and 200 part time employees, Corcoran Commons, one of BCDS' largest dining halls, serves over 8,000 students every day (Russo 2017). Corcoran Commons also serves as a primary testing ground for creative and sustainable food options. In working towards BCDS' mission of fostering "a culture in which the interwoven benefits of

growing, cooking and sharing food become an integral part of the University's community experience," Corcoran Commons sources its ingredients from "local growers, manufacturers and vendors who respect and promote ecologically sensitive agricultural practices, and food distributors who can trace their products to responsible sources" ("Sustainability"). For these reasons, Corcoran Commons was selected as the data collection site for this study.

In January 2017, Boston College began working with other MCURC member schools – Stanford University, Harvard University, Rutgers University, and Lebanon Valley College – to coordinate the simultaneous administration of a standardized beef substitution experiment. Boston College administered the experiment on Wednesday, March 1st 2017.

II. METHODS

Before administering the experiment, Institutional Review Board (IRB) approval was sought because human subjects were to be studied. Information on the following topics were compiled and submitted as part of the formal IRB application: general study information, research summary, research risks and benefits, research site, and investigators involved. Because the experiment was a taste test with minimal risk to participants, an exemption under 45 CFR 46.101 (b) 6 was sought. Exemption approval was granted on February 27th 2017 (see Exhibit 1).

Participants

Study participants were Boston College undergraduate students ages 18-23 who volunteered to participate during dinner service in Boston College Dining Services' Corcoran Commons on Wednesday, March 1st 2017. The study only excluded from its sample population vegetarians, pregnant women, and individuals with known food allergies (see Exhibit 2).

Materials

Stanford University shipped to BCDS six hundred (600) precooked and frozen meatballs,

one hundred fifty (150) of each of the following ratios of mushroom-to-beef: 60:40; 50:50; 40:60; and 0:100. The meatballs contained only two ingredients: grass-fed beef and white button mushrooms. The meatballs included no seasoning, spices, herbs, binders, or breadcrumbs. For more information regarding this aspect of study design, please see ***Shortcomings***.

Data Collection

At 6 p.m. on Wednesday, March 1st 2017, four high-top tables were aligned in Corcoran Commons. On one end were four chafing dishes labeled A, B, C, and D. Each chafing dish held 150 samples of a particular meatball blend. Participants were given no indication as to which meatball blends were which; this was a single-blind study. On the other end of the tables were four sheets with large A, B, C, and D printed letters. An iPad accompanied each sheet. Just below these letters were four cups, each holding a sample meatball. Undergraduate students participating in the study ate the four meatballs and recorded on a standardized hedonic scale their rankings of various gastronomic qualities. These qualities were:

1. Flavor
2. Juiciness
3. Texture/Tenderness
4. Appearance
5. Likelihood to Eat (if offered in the dining hall)

Participants used iPads to complete a Google Forms survey which transferred data into Google Sheets. The original survey, prior to being adapted into Google Forms, is attached as Exhibit 3. Participants were also asked to provide their age, gender, dining location habits, beef consumption habits, and when they participated in the study (i.e. before, during, or after their meal). Participants were not required to finish all of the meatballs; many chose to take one bite of each and then record their evaluations. Once participants had tasted each meatball and completed

the survey, the survey was reset and the tasting station was renewed with four new meatballs from the respective chafing dishes. A total of 126 responses were collected.

Analysis

After data collection had ended, all data were transferred from Google Sheets to Microsoft Excel and SPSS. Microsoft Excel was used for general descriptive analysis while SPSS was used for more targeted analyses.

III. RESULTS

Two descriptive data analyses were performed. First, Figure 1 below shows the popularity of each meatball. In this analysis, popularity is defined as the percentage of respondents who ranked a given meatball as their "top choice." As Figure 1 shows, Meatball D (100% beef) was the most popular with 44.4% of respondents selecting it as their top choice. Of the blended meatballs, the 50% beef blend was the most popular (21.4%), followed by the 60% beef blend (17.5%) and the 40% beef blend (16.7%).

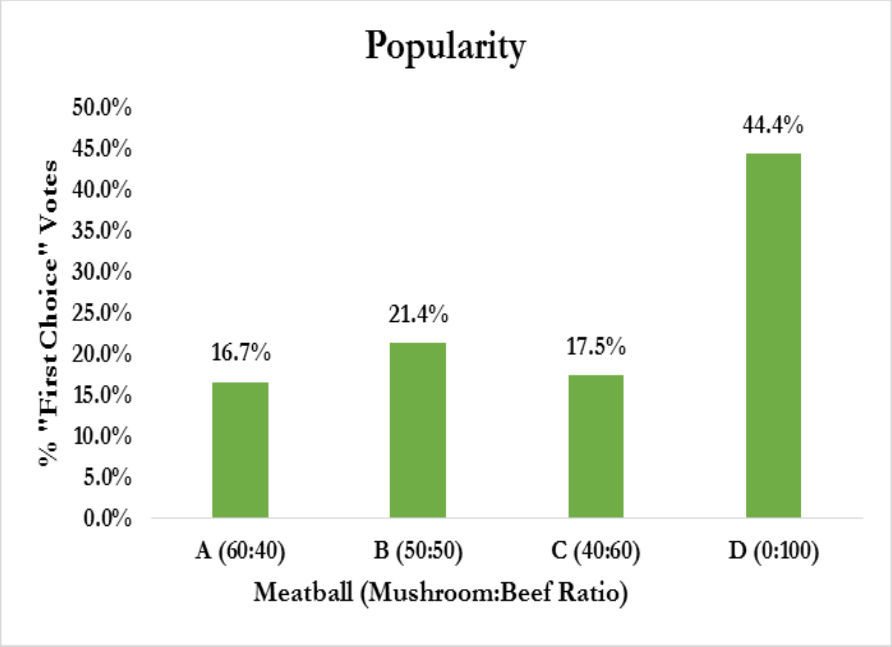

Figure 1. Popularity of four meatball blends as indicated by percentage of "first choice" votes.

Second, Figure 2 below shows the average overall rating of the five qualities for each meatball. The average overall rating was calculated by averaging the mean ratings of each of the five qualities (flavor, juiciness, texture/tenderness, appearance, and likelihood to eat if offered in the dining hall) for each blend. Each quality was ranked from 1 to 5. As Figure 2 shows, the meatball with the highest average overall rating was Meatball D (100% beef) with a 3.33/5.00. In a close second, Meatball B (50% beef) received an average overall rating of 2.93/5.00, which translates into only an 8% difference.

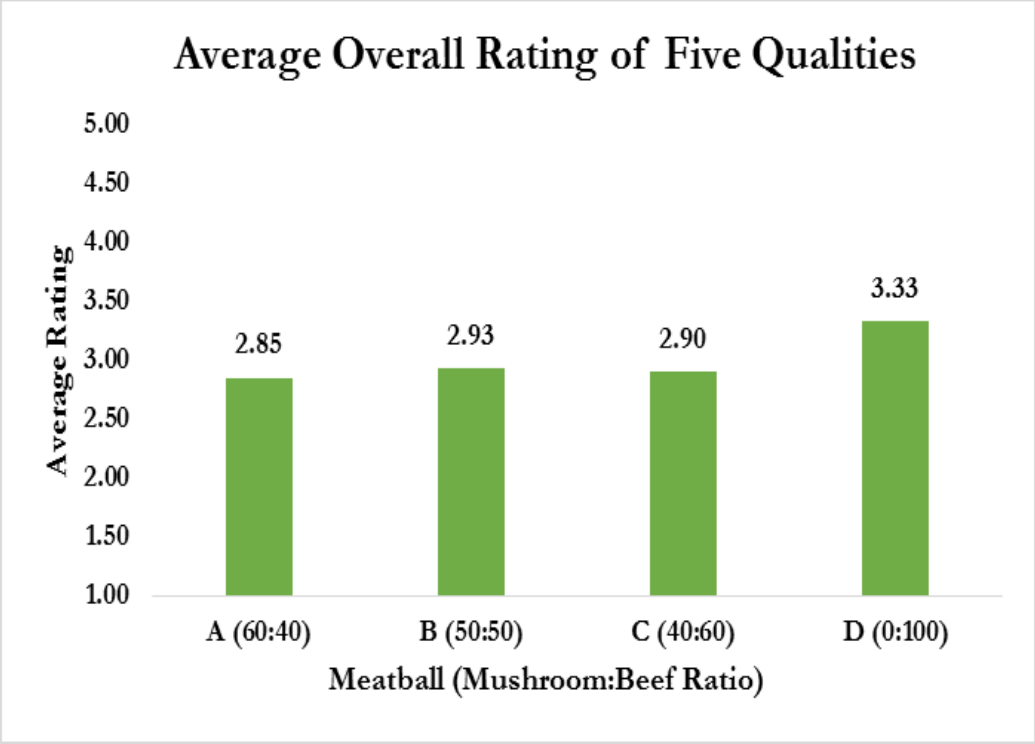

Figure 2. Average overall rating by meatball blend.

Together, Figure 1 and Figure 2 show that the order of popularity (D, B, C, A) aligns with the order of average overall ratings (D, B, C, A). This proves that the sample population was consistent and logical in their evaluations.

Table 1

One Way ANOVA Post Hoc Tukey Test

Dependent Variable: Gender

Tukey HSD

(I) First Choice	(J) First Choice	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1	2	.8842	1.9679	.992	-4.498	6.267
	3	-.7008	1.9746	.997	-6.102	4.700
	4	-2.5141	1.7147	.585	-7.204	2.176
	99	-47.9353*	4.2979	.000	-59.691	-36.179
2	1	-.8842	1.9679	.992	-6.267	4.498
	3	-1.5851	1.8605	.914	-6.674	3.504
	4	-3.3983	1.5820	.201	-7.725	.929
	99	-48.8195*	4.2467	.000	-60.435	-37.204
3	1	.7008	1.9746	.997	-4.700	6.102
	2	1.5851	1.8605	.914	-3.504	6.674
	4	-1.8133	1.5902	.785	-6.163	2.536
	99	-47.2345*	4.2498	.000	-58.859	-35.610
4	1	2.5141	1.7147	.585	-2.176	7.204
	2	3.3983	1.5820	.201	-.929	7.725
	3	1.8133	1.5902	.785	-2.536	6.163
	99	-45.4212*	4.1355	.000	-56.733	-34.110
99	1	47.9353*	4.2979	.000	36.179	59.691
	2	48.8195*	4.2467	.000	37.204	60.435
	3	47.2345*	4.2498	.000	35.610	58.859
	4	45.4212*	4.1355	.000	34.110	56.733

*. The mean difference is significant at the 0.05 level.

Table 1 above highlights the statistical significance between gender and top choice of meatball.[2] As is observable in Table 1, the significance of the selection of "1" (Meatball A) as top choice was .992. The significance of the selection of "2" (Meatball B) as top choice was also .992. The significance of the selection of "3" (Meatball C) as top choice was .997. Notably, the significance of the selection of "4" (Meatball D) was .585. That is to say, the gender of respondents who selected Meatball D as their top choice was not significant; both genders rated Meatball D

[2] In Table 1, "99" is the value for missing data. It is has no relevance to this analysis.

similarly. However, the gender of respondents who selected *any* other blend as their top choice was very significant. In sum, the choice of 100% beef (Meatball D) was not a gendered response. Preferences between blended meatballs, however, did depend significantly on respondents' gender.

In general, there was no correlation between top choice and gender – see Table 2 below, in which the Pearson Correlation was .409. This is likely due in part to the strong overall preference for Meatball D, which as discussed above, did not implicate gender as a significant factor.

Table 2

Correlation between First Choice and Gender

		First Choice	Gender
First Choice	Pearson Correlation	1	.409**
	Sig. (2-tailed)		.000
	N	704	675
Gender	Pearson Correlation	.409**	1
	Sig. (2-tailed)	.000	
	N	675	675

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

IV. DISCUSSION

Our results indicate that of the four blends tested, the 100% beef meatball – the control – was the most popular, with about 44% of respondents selecting it their favorite. The control was more than twice as popular as the next most popular offering, the 50% beef blend, which earned about 21% of respondents' top choice votes. The 60% beef blend earned about 18% of top choice votes, followed by the 40% beef blend, which earned about 17%. While these data solidify the control as the top choice, they also highlight an opportunity for reducing beef consumption. Given that the control earned 44% of top choice votes, the majority of respondents (56%) preferred a blended meatball. This fact is critically important in analyzing the study's strengths and

shortcomings, identifying its contribution to the scientific literature, and synthesizing recommendations.

Strengths

The strengths of this study were interscholastic coordination, the digitalization of the survey, and the replicability of the experiment. Through an email chain and shared documents, study investigators communicated both problems and progress. The research team also participated in video conferences, which were avenues for sharing developments and forums for questions, suggestions, and concerns.

The decision to digitalize the survey was important not only because it eliminated paper waste during data collection but also because it simplified data analysis. Manual data entry was minimal and missing data never occurred because the survey was designed in such a way as to require answers to every question before proceeding.[3]

The replicability of this experiment is high. In fact, the MCURC plans to administer this study alongside other meat substitution studies throughout the coming year. Replicability is important for any study, but particularly so in this case given that one of the MCURC's ultimate objectives is determining the optimal mushroom-to-beef blend.[4]

Shortcomings

The shortcomings of this study were its timing, certain decisions made during study design, and potentially impactful yet untested attributes. The study administration date range coincided with the Christian holiday of Lent, during which many Christians do not consume beef. During the course of the study administration, many students expressed interest in participating until they were informed of the beef content. These students had no choice but to refrain from participating

[3] The missing data in Table 1 originates from other administrations of this study, most of which used paper surveys.
[4] For authors' suggestions on determining the optimal blend, see ***Recommendations for Future Studies***.

in the study. This had two effects: (i) it potentially reduced the number of participants[5] and (ii) it narrowed the sample population to exclude students who refrained from participating due to Lent.

During study design in the fall of 2016, study investigators decided to test the blends alone (i.e. with no condiments, toppings, or sauces). At some point thereafter, Stanford University chefs decided that in order to ensure structural integrity during shipping, the meatballs would contain no seasoning, spices, herbs, binders, or breadcrumbs. During the study administration, some participants commented on the meatballs' "wateriness" and under-seasoning, with some suggesting that a more realistic taste test would have supplied meatballs in preparations similar to the way in which they would typically be served. Some participants explained that this meant including salt and pepper, while others said spices and herbs should have been added. Others still expressed confusion regarding the rationale behind serving the meatballs without any accompanying sauce, contending that meatballs are not usually eaten without sauce. This last issue had been addressed by the study design team, which decided that in order to execute an accurate taste test, sauces would be excluded. The team reasoned that sauces could suppress subtle differences between the blends.

Although this study asked participants to rank the blends on four gastronomic qualities (flavor, juiciness, texture/tenderness, and appearance) and one composite likeability metric ("likelihood to eat if offered in the dining hall"), other untested qualities could exist. Such qualities could include suitability for use with sauces, perceived umami, or any other qualities with potentially significant impacts on palatability.

Contribution

As a study of food quality perceptions, this research builds upon the quantitative literature

[5] 126 of 150 surveys were completed.

concerning the partial displacement of ground beef with mushrooms. Through its focus on substituting beef with plant alternatives, this study also contributes to the scientific literature on sustainable food systems. Future research into questions raised by this study could include a lifecycle analysis comparing beef production with mushroom production, the financial practicality of introducing a beef substitution product on the university scale, other viable beef substitution ingredients, encouraging beef substitution practices in the home, and incentivizing beef substitution practices in restaurants and organizations not affiliated with a university.

Recommendations for Future Studies

The authors of this report make two recommendations for future researchers. First, in designing beef substitution studies, it is important to consider the qualitative respondent feedback collected during this study. This feedback includes respondents' desires for seasoning, spices, and herbs, which could be standardized across the blends. This feedback also includes comments made about the "wateriness" of certain blends. Given that mushrooms are roughly 90% water, we recommend par-cooking them to reduce their water content ("Water Content of…").

Second, given five administrations with over 700 total respondents, we recommend that future researchers reevaluate the blend ratios. In this study, three out of the four meatballs were within 20% mushroom content of each other (40%, 50%, and 60%), while the fourth meatball – the control – contained none. These ratios assume that the average respondent is capable of discerning a 10% change in mushroom content and is capable of expressing why one blend is preferable over another. We therefore recommend experimenting with larger ratio ranges.

Through repeating this study with similarly large sample populations, future researchers could continually modify the ratios in an effort to achieve the statistically "perfect" blend: a mushroom and beef meatball that consistently ranks highest in top choice votes. We suggest the

following evenly-distributed ratios of mushroom-to-beef for future studies, at least until such time as a revision should be made based upon observed trends: 60m:40b; 40m:60b; 20m:80b; 0m:100b.

Recommendations for Boston College Dining Services

Boston College Dining Services is positioned to directly benefit from this study. Given this consumer data, we conclude that in order to reduce beef consumption on campus, BCDS should further refine and retest the blends, beginning with the most popular 50% beef blend. Through future student evaluations, BCDS may be able to develop recipes that make the 50% beef blend as appealing as (or potentially even more appealing than) the 100% beef meatball. Now outside the limitations of replicable scientific studies, BCDS has discretion over seasonings, sauces, and other flavor-enhancing ingredients. In this way, BCDS can focus its efforts on integrating student evaluations with sustainable menu design. Given BCDS' numerous ground beef offerings, including burgers, chili, meatballs, nachos, quesadillas, and other ethnic foods, BCDS has the opportunity to become a leading university dining service in reducing beef consumption.

V. REFERENCES

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VI. APPENDIX

BOSTON COLLEGE
Institutional Review Board
Office for Research Protections
Waul House, 3rd Floor
Phone: (617) 552-4778, fax: (617) 552-0498

IRB Protocol Number: 17.169.01e

DATE: February 27, 2017

TO: DEAN A ELWELL

CC: Tara Pisani Gareau

FROM: Office of Research Protections

RE: MC-URC Protein Flip Mushroom:Beef Blend Taste Test

Notice of Evaluation – [Exempt 45 CFR 46. 101(b)] 6

The Office for Research Protections (ORP) has evaluated the project named above. This is a minimal risk study that has been granted an exemption from Boston College IRB review in accordance with 45 CFR 46.101 (b) 6. This designation is based on the assumption that the materials that you submitted to the ORP contain a complete and accurate description of all the ways in which human subjects are involved in your research

This exemption is given with the following conditions:

1. You will conduct the project according to the plans and protocol you submitted;
2. No further contact with the ORP is necessary unless you make changes to your project or adverse events or injuries to subjects occur;
3. If you propose to make any changes in the project, you must submit the changes to the ORP for IRB review; you will not initiate any changes until they have been reviewed and approved by the IRB;
4. If any adverse events or injuries to subjects occur, you will report these immediately to the ORP.

Exhibit 1. Boston College Institutional Review Board Notice of Evaluation - 45 CFR 46. 101(b) 6.

Meatball Taste Test

Corcoran Commons

March 1st 6pm

Come join us for a mushroom:beef taste test!**

We're seeking taste testers who want to help us create new flavors in the dining hall.

Your input will provide us with valuable feedback.

This taste test is not appropriate for (1) vegetarians, (2) pregnant women, and/or (3) **individuals who have known food allergies.**

Questions, Concerns, or Complaints: If you have any questions, concerns or complaints about this research study, its procedures, risks and benefits, or alternative courses treatment, you should ask the Protocol Director. You may contact Christopher Gardner now or later at 650-725-2751.

Protocol Title: MC-URC Protein Flip Mushroom:Beef Taste Taste
Protocol Director: Christopher D. Gardner
IRB Approval Date: 01/31/2017 **IRB Expiration Date:**

Exhibit 2. Standardized MCURC flyer; posted in Corcoran Commons prior to and during the study administration.

MCURC THE MENUS OF CHANGE UNIVERSITY RESEARCH COLLABORATIVE

Survey Number _____

Please rate each meatball for each category, on a scale of 1-5 as follows:

1- Very dissatisfied
2 - Somewhat dissatisfied
3 - Neutral
4 - Somewhat satisfied
5 - Very satisfied

Meatball	Flavor	Juiciness	Texture/ Tenderness	Appearance	Likelihood to Eat (if offered in dining hall)
A					
B					
C					
D					

Overall Preference (ranking of preferred meatballs):

1st choice _____
2nd choice _____
3rd choice _____
4th choice _____

Roughly what percentage of meals do you eat **in the dining hall (not including other campus restaurants)**?

0% 25% 50% 75% 100%

How often do you eat beef **in the dining hall**?

0-2 meals/week 3-5 meals/week 6-10 meals/week 11+ meals/week

How often do you eat beef **outside of the dining hall**?

0-2 meals/week 3-5 meals/week 6-10 meals/week 11+ meals/week

I participated in this taste test:

Before my meal _____ During my meal _____ After my meal _____

Age _____ Gender _____

Data Entered _____

Exhibit 3. Standardized MCURC survey; later digitalized into a Google Form.