Fitness Lunch Bag: the ability to keep foods cold and out of the danger zone

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Background: Improper storage of food is one of the top ten food handling practices that cause a foodborne illness. This study assessed whether the Fitness Lunch Bag was able to keep precooked chicken breast cold at below 4°C (40°F) for 8 hours and to determine if the layers of the bag kept food consistent at the same temperature.
Methods: Three SmartButtons, continuous temperature data logging devices, were inserted into three precooked and chilled chicken breasts. The three chicken breasts were placed within three trays inside the Fitness Lunch Bag that remained at room temperature for 8 hours. The internal temperatures were logged at one hour intervals. A total of 30 samples were collected. NCSS was used for statistical analysis of the data by regression/correlation and ANOVA.
Results: The Fitness Lunch Bag was unable to hold cold food safely, at 4°C (40°F) and below for 8 hours. All three layers were found to exceed 4°C (40°F) within the first hour (p-value of 0.000 by 1 sample t-test). In addition, all three layers of the Fitness Lunch Bag were found to not be equivalent in retaining a consistent temperature throughout the bag (p-value of 0.000000 < 0.05 by regression analysis at the 8 hour mark). Layer 2 was the best at retaining the lowest temperature for the chicken breasts, followed by layer 1. Moreover, layer 3 was found to display the warmest temperatures out of the three layers.
Conclusion: The results of the study show that the Fitness Lunch Bag does not have the ability to keep cold foods out of the danger zone, 4-60°C (40 – 140°F), for 8 hours. In addition, the bag was not capable of keeping cold foods safe at the 1 hour mark. Caution should be used with any type of lunch bag, insulated and/or frozen gel packed, especially with the potentially hazardous foods.

Key words: lunch bag, foodborne illness, temperature, temperature abuse, fitness.

Introduction

Many people, including athletes, body builders and gym goers, choose to eat healthy foods in order to reach their fitness goals. These people often prepare their meals in advance by cooking it the day before and by cooling the food so it can be eaten the following day. These meals usually consist of boiled or stemmed vegetables, cooked whole grains like brown rice or quinoa, and potentially hazardous foods like grilled chicken breasts and grilled fish. The advantage of meal prepping is to ensure that people stick to a strict meal plan and that they do not stray from it. However, the disadvantage of meal prepping is that improperly handled or contaminated food can cause a food borne illness. The effects of food borne illness range from minor discomfort to severe symptoms such as acute illness, adverse chronic health effects and even death (International Association for Food Protection, 2011). Therefore, it is critical to keep cold foods cool when packing meals to eat on the go for breakfast, lunch, snack or dinner.

Fitness Lunch Bag created a line of innovative portable bags to tailor to health and fitness oriented people who eat their meals on the go. These upgraded lunch bags help consumers to make eating healthy foods easily accessible and to keep foods safe during the day. However, whether these bags can truly keep food out of the danger zone is questionable.

Literature Review

Foodborne Illness

In 2013, it was estimated there were 4 million of food borne illness cases a year that were acquired domestically in Canada (Public Health Agency of Canada, 2013). The most common pathogens that contribute to domestically acquired food borne illnesses are: norovirus, Salmonella (nontyphoidal), Clostridium perfringens, Campylobacter spp., and Staphylococcus aureus (CDC, 2012). Cases of food borne illness frequently occur but they often go underreported. For every one reported food poisoning case, there are 347 unreported cases (Taylor, 2013). There are many contributing factors that lead to a food borne illness. Improper cooling is the number one cause of food borne illness outbreaks,

which is followed by advanced preparation as the second most likely cause (BCCDC – Food Protection Services, 2009). Therefore, it is important to keep cold foods cold for consumption the next day if the food was made in advance.

Time and Temperature Abuse

In order to keep foods safe for consumption, the Food Premise Regulation states that potentially hazardous food must be stored or displayed at a temperature or 4°C and below or 60°C and above (2013). The Canadian Food Retail and Food Services Code states that a potentially hazard food is a food that contains milk, milk products, eggs, meat, poultry, fish, shellfish, or any ingredient that is capable of supporting growth of pathogens with a pH level higher than 4.6 and water activity of 0.85 or above (Canadian Food Inspection System Implementation Group, 2004). The temperature range from above 4°C to below 60°C is called the danger zone because it is the optimal temperature that supports the growth of pathogens (British Columbia FOODSAFE Secretariat, 2006). When there are favorable conditions for growth, bacteria can double every 20 minutes (Harvard Women's Health Watch, 2011). In addition, certain pathogens can produce toxins and contribute to food borne illnesses (NSW Food Authority, 2008).

In order to reduce the opportunity of pathogen growth and toxin production, the temperature of the foods must be controlled. The pathogenic generation rate is slowed down at cold temperatures, at 4°C and below, and at hot temperatures, at 60°C and above. For cooked foods or left overs, it is important to cool foods quickly within adequate time and temperatures to deter opportunity of pathogen growth. It is recommended that previously cooked potentially hazardous foods, that will be refrigerated for cold storage, are to be cooled from 60°C (140°F) to 20°C (68°F) or less within two hours and then from 20°C (68°F) to 4°C (40°F) or less within 4 hours (Canadian Food Inspection System Implementation Group, 2004). It is critical to maintain temperatures outside of the danger zone in order to keep food safe for consumption.

Current Practices

In the absence of refrigeration, there are several recommended methods that can extend the time that food can stay cold. The use of an insulated bag, an ice pack or both an insulated bag and an ice packs are the most common methods.

Insulated Bag Only

The brown paper lunch bag is a standard method of containing and transporting meals on the go. However, a brown paper bag only serves as means of transport and not a means of keeping foods cold. Insulated bags were created by many brands such as Canadian Thermos™, California Innovations™, Arctic Zone™, Ice Cubed™, and Media™. In comparison with the brown paper bags, insulated bags are leak proof, easier to clean, durable and most importantly, they have a high density thermal insulation to keep meals fresh (California Innovations™, 2012). The goal of insulated bags was to keep hot foods hot and cold foods cold while being stored at room temperature. However, whether the insulated bags truly keep foods out of the danger zone, above 4°C to below 60°C, is questionable.

A study was conducted to test the ability of various insulated lunch bags to keep potentially hazardous foods cold at room temperature. The researcher used a brown paper bag as a control, due to the lack of insulation, and used different brands of insulated bags to hold an egg salad sandwich cold (Wong, 2004). An egg salad sandwich was selected as a potentially hazardous food because of the inherent nature of eggs. Eggs have a high moisture content and are high in protein (Wong, 2004). The researcher measured the internal temperature of the egg salad sandwich continuously for 5 hours with a Two Commtest Instruments TM MMS-3000-T6V4 Datalogging Thermometers by inserting the device through a small exposed opening of the insulated bag (Wong, 2004). This measuring technique was carried out because of the limited technology available in the past. The small opening of the insulated bag, where the thermometer was inserted, may have some effect on the temperature measurements due the ambient temperature. Regardless, the study showed that the insulated lunch bags, that were tested, were not effective in keeping an egg salad sandwich below 4°C (Wong, 2004). This method of using insulated bags should be used with caution and with consideration of perishable foods.

Ice Pack Only

One method is to freeze food, like a sandwich, so it can act like an ice pack. The frozen food can be placed into a non-insulated lunch bag, to keep other perishable foods cold, and it will thaw out before consumption (Washington State University, 2001). However, the quality of the frozen food may be diminished, depending on the ingredients, by the freezing and thawing process (Washington State University, 2001). This method may or may not work well since some foods freeze well and some do not.

Another method is to freeze a juice box, which acts like an ice pack, and place it in a non-insulated lunch bag to keep perishable foods cold for a longer period of time (Washington State University, 2001). The frozen juice box will thaw out at room temperature before the time of consumption. This method would maintain the quality of the beverage since it would not be diminished like thawing frozen food. However, the use of an ice pack or frozen food/beverage items does not sufficiently keep foods cold in a non-insulated bag. This fact was highlighted by a study that found over 90% of non-insulated lunch bags with no ice packs, one ice pack or more ice packs placed inside, do not keep perishable foods safe below the danger zone of 4-60°C (Almansour et al., 2011). The researchers opened the non-insulated lunch bags 1.5 hours prior to the consumption of food and measured the temperature of the foods with a non-contact temperature gun (Almansour et al., 2011). A non-contact temperature gun uses infrared rays to measure the surface temperature of an object (All QA, 2011). In turn, this method does not measure the internal temperatures of solid food. It is common for food to have a temperature gradient depending on the type and size. Regardless of the temperature measuring technique, the study found 97.4% of the meats, 99% of dairy and 98.5% of vegetables in the packed lunches were temperature abused within the range of above 4°C to below 60°C (Almansour et al., 2011). Overall, the study gathered data to show that the presence or absence of ice packs or a frozen food/beverage cannot keep perishable foods safe before the time of consumption.

Previous studies have focused only on one factor of keeping foods at safe at ambient room temperature, such as either using an insulated bag or ice packs. Further research is needed to determine food safety at ambient room temperature with multiple factors such as the combination of an insulated bag with ice packs.

Fitness Lunch Bag

A revolutionary lunch bag was created by Fitness Lunch Bag that encompasses both aspects of an insulated bag and ice packs. The Fitness Lunch Bag 300 bag is an insulated bag that consists of two reusable gel packs that can be frozen and be placed inside to keep foods safe. The most common type of foods that are stored in a Fitness Lunch Bag are foods that have high protein such as poultry, fish, and eggs. Health and fitness oriented individuals consume high protein foods to increase muscle mass and lose body fat. Foods with high protein content are potentially hazardous foods because of high water activity and high pH (Institute of Environmental Science & Research Ltd, 2004). It is critical to keep potentially hazardous foods safe for consumption and out of the danger zone.

On the company website, the Fitness Lunch Bag claims to keep foods safe at 8 hours and more. However, there appear to be no research studies on the efficacy of an insulated lunch bag, which utilizes ice packs, to keep foods safe. The purpose of this research was to determine the ability of the Fitness Lunch Bag 300 from Fitness Lunch Bag to keep cold foods out of the danger zone (above 4°C to below 60°C) at ambient room temperature.

Methods

The day before experiment, three chicken breasts were baked in the oven at 350°F for 30 minutes without any added ingredients. The chicken breast's temperature was measured by a Marathon digital instant read thermometer (Marathon Watch Company Ltd, 2013). The internal temperature of poultry was measured to ensure adequate cooking achieved at a reading of 85°C (185°F) or higher for 15 seconds (CFISIG, 2004). The three cooked chicken breasts were transferred immediately into three respective Fitness Lunch Bag containers. Then, the three containers were placed in a refrigerator overnight to cool down to 4°C (40°F) or lower.

On the day of experiment, a SmartButton was incorporated into one chicken breast by wrapping the chicken around the measuring device. For complete coverage of the SmartButton, the two exposed ends were tied, to seal up the gaps, with an elastic band at each end. The SmartButton recorded the continuous temperature for a span of 8 hours. A total of three SmartButtons were used for three chicken breasts during one sample collection. The chicken breasts were placed back into the containers and into the Fitness Lunch Bag. Afterwards, two previously frozen Fitness Lunch Bag gel packs were placed vertically in the slots of the Fitness Lunch Bag to keep the interior compartment cool. The bag was then left out at ambient room temperature.

ACR SmartButton

The TrendReader software was installed on a PC computer. The parameters of the SmartButton set up was outlined as: Data collection interval was 1 hour, Memory usage was stop when full, and Start time was as desired. The data was retrieved by placing the SmartButton into the reader. To access the collected data on the computer, the BCIT Food Technology assistant instructor advised the researcher to select

the BACKUP option (K. Keilbart, personal communication, November 12, 2013). The data was displayed in a table and a temperature graph was produced. Under the Data Table tab option, the time and temperatures were displayed. The data was then exported into a statistics program, NCSS (Hintze, 2013), to be analyzed.

Reliability and Validity of Measures

To increase the reliability of the results, 30 trials were performed. Each trial contains 3 samples: 3 chicken breasts, since the Fitness Lunch Bag 300 has a 3 layer compartment system with 3 food containers. In total, 90 chicken breasts were sampled within the 30 trials. The same researcher conducted the experiment on the same Fitness Lunch Bag for a total period of 8 hours each time to increase reliability measures.

To ensure validity, two Marathon digital instant read thermometers were calibrated before the start of the experiment. The first digital thermometer was used to ensure the temperature of the refrigerator where the chicken breasts was held overnight was 4°C or less (40°F or less). The second digital thermometer was used to probe the internal temperature of the chicken breasts to ensure it complete cooking at 85°C or more (185°F or more) for 15 seconds. The SmartButton is factory calibrated with an accuracy of: ±1.0°C from - 30.0°C to 45°C (±1.8°F from -22.0°F to 113°F) (ACR Systems Inc., 2012a).

Results

The temperature change of chicken breasts was logged against the time in each trial. The time and temperature data collected by the SmartButton was continuous and numerical. The specific temperature of the 3 chicken breasts was determined at every one hour time interval up to 8 hours.

Figure 1 – Layers within Fitness Lunch Bag 300

Table 1. Descriptive statistics on temperature (°C) of chicken breast in three layers of containers during an 8 hour period

	Layer 1	Layer 2	Layer 3
Mean	11.5	10.8	14.3
Median	11.5	11	14.5
Mode	11	11	14.5
Standard Deviation	1.0	0.8	1.2
Range	5.5	4.5	7

Minimum	9	8.5	10.5
Maximum	14.5	13	17.5
Sum	2762.5	2603.5	3433.5
Count	240	240	240
Total Count of all Layers	720		

Descriptive Statistics

The containers within Fitness Lunch Bag were labeled from the top to bottom of the bag respectively as Layer 1 (top), Layer 2 (middle) and Layer 3 (bottom) outlined in Figure . Microsoft Excel (Microsoft Corporation, 2007) was used to generate descriptive statistics for the 720 counts of data points collected during the 30 trials (See Table 1). The descriptive statistics examined the temperatures in Celsius within the three layers with respect to time in hours. In Table 1, the means and standard deviations during the 8 hour period were 11.5 ± 1.0, 10.8 ± 0.8 and 14.3 ± 1.2 for Layers 1, 2, and 3 respectively.

Inferential Statistics

In this project, two hypotheses were tested with the use of NCSS (Hintze, 2013). See Table 2.

The temperature changes of chicken breast were collected at hourly interval times from 1 to 8 hours (hour 1, 2, 3, 4, 5, 6, 7 and 8). Linear regression and correlation analysis were performed on the data collected at layer 1, 2 and 3 to determine the correlation between temperature and time for hypothesis 1. The temperatures of layer 1, 2 and 3 was used to determine when, in hours, the danger zone (4 – 40°C or 40 – 140°F) was reached, if it was ever reached. In addition, ANOVA was performed for a one-way analysis of variance to determine a difference in chicken breasts temperatures that were stored at positions of layer 1, 2 or 3 for hypothesis 2.

Research Findings – Regression Analysis

The study found a positive linear correlation between time and mean chicken breast temperature. As the holding time increased, the temperature of the chicken breasts increased as well. The change in temperature could be predicted by the change in time with the use of the slope and intercept (See Table 3) to create a linear regression equation model. For example, the equation for each layer would be chicken breast temperature in °C = y + slope (time in hours).

Therefore, if the time of interest was for 2 hours, then the equation (y= mx +b) for Layer 1: °C = 10.1738 + 0.2970 (2 hours). In Layer 1, the chicken breast temperature was calculated to be at approximately 10.8°C at the 2nd hour. The same calculation was done for Layer 2 and 3 with their respective formulas, Layer 2: °C = 9.7470 + 0.2446 (2 hours) = 10.2°C and Layer 3: °C = 13.3482 + 0.2129 (2 hours) = 13.8°C. The time of 2 hours was chosen because that is the maximum amount of time food for immediate consumption was recommended to be stored at room temperature from the Food Retail and Food Services Code (Canadian Food Inspection System Implementation Group, 2004).

The correlation coefficient indicated there was a moderate to good relationship ($0.50 \leq R \leq 0.75$) for layer 1 and 2 (Heacock, H. and Sidhu, B., 2013b). However, despite the lower correlation coefficient of layer 3 (R =0.4015), there was still a fair degree of relationship ($0.25 \leq R \leq 0.50$) that existed (Heacock, H. and Sidhu, B., 2013b).

The researcher rejected the Ho and was able to conclude that there was a statistically significant correlation between temperature and time due to the strong power and probability level is less than 0.05 (See Table 3). The temperature of the chicken breasts would increase significantly over time in hours. The author determined that the Fitness Lunch Bag was not able to keep cold foods cold at 4°C (40°F) for at Layer 1, 2 and 3 at the 8 hour mark despite the claim made by the Fitness Lunch Bag website.

Research Findings – ANOVA

One-way ANOVA analysis of variance (see Table 4) was used to determine if there was a difference in chicken breast temperature at hour 8 throughout all the layers 1,2 and 3 of the Fitness Lunch Bag. The data was normally distributed at hour 8 so a parametric test was performed. However, there was no statistically significant difference in the mean chicken temperature at hour 8 between layers 1, 2 and 3. The p-value was 0.000000, therefore reject Ho and conclude that the temperature of layer 1,2 and 3 are not all the same after 8 hours. This suggests that each layer is not equivalent at keeping food at the same temperature.

At the 8 hour mark, the Ho was rejected due to

the statistically significant probability level of 0.000000 and then the post hoc test, Scheffe's multiple comparison test was examined . The Scheffe's Multiple Comparison Test (see Table 4) stated that the first layer is different from 2nd and 3rd layer. In addition, second layer is different from 1st and 3rd layer. Finally, the third layer is different from 1st and 2nd layer. In summary, the three layers are all different from one another.

Table 2. Hypotheses tested.

Hypothesis 1: Regression Analysis	
H_o: slope = 0	H_o : There is no difference in the mean chicken breast temperature within a specific layer of Fitness Lunch Bag container as the holding time increases from 1 to 8 hours. i.e. slope = 0
Ha: slope $\neq 0$	Ha : There is a difference in the mean chicken breast temperature within a specific layer of Fitness Lunch Bag container as the holding time increases from 1 to 8 hours. i.e. slope $\neq 0$
Hypothesis 2: ANOVA	
H_o: $\mu_1 = \mu_2 = \mu_3$	Ho : There is no difference in the chicken breast temperature in the layer 1, 2, and 3 of the Fitness Lunch Bag™ bag at the 8 hour mark
Ha: $\mu 1 \neq \mu 2 \neq \mu 3$	Ha : There is a difference in the chicken breast temperature in the layer 1, 2, and 3 of the Fitness Lunch Bag™ bag at the 8 hour mark

Table 3. Linear regression and correlation of time (hours) on temperature (°C) of chicken breast at Layer 1, 2 and 3 of the Fitness Lunch Bag™ bag

Layer	Slope	Y-intercept	Correlation (R)	Probability Level	Reject H_o	Power (alpha = 0.05)
1	0.2970	10.1738	0.6747	0.0000	Yes	1.0000
2	0.2446	9.7470	0.6618	0.0000	Yes	1.0000
3	0.2129	13.3482	0.4015	0.0000	Yes	1.0000

Table 4. ANOVA: Scheffe's Multiple Comparison Test

Group	Count	Mean	Different From Groups
1	30	12.65	2,3
2	30	11.81667	1,3
3	30	15.06667	1,2

One-Sample T-test

Within the first hour of packing the chicken from the refrigerator to the Fitness Lunch Bag™ bag, the researcher noted that the temperature exceeded 4°C or 40°F. A One-Sample T-test, also known has a One-way ANOVA analysis of variance, was performed to determine whether the chicken temperatures at the 1 hour mark, which were all within the danger zone, were statistically significantly greater than 4°C or 40°F for each layer.

The results show that Layer 1 had a p-value of 0.000002 with 100% power, Layer 2 had a p-value of 0.0000 with 100% power, and Layer 3 had a p-value of 0.0000 with 100% power. Hence, for each layer at hour 1, the temperatures were statistically significantly greater than 4°C or 40°F. The data was not normally distributed at hour 1 so a non-parametric test, Kruskal Wallis, was examined. At hour 1, the p-value was 0.07, which means that Ho was accepted. Therefore, there was no statistically significant difference of temperatures at each layer. This suggests that each layer is equivalent at keeping food at the same temperature at the one hour mark.

Discussion

Insulated lunch bags with frozen gel pack inserts, are an innovative food preparation and storage method used by people who live a healthy lifestyle. The new technology has raised concerns due to the absence of studies conducted on the effectiveness of these specific lunch bags. The inability to keep cold foods stored at or below 4°C (40°F) gives the opportunity for microorganisms to multiply on the food once the temperatures enter the danger zone (Harvard Women's Health Watch, 2011). The analysis of the data revealed that the Fitness Lunch Bag™ bag was not effective in keeping chicken breasts cold at 4°C (40°F) and below for a period of 8 hours.

According to the regression analysis, there was statistical significance (p value = 0.0000 for all layers in Table 3) between the difference in the mean chicken breast temperature and the holding time in hours. The data showed a positive correlation between an increase of time from 1 to 8 hours and an increase of the mean chicken breast temperature. Fitness Lunch Bag stated that it has the ability to keep foods safe for 8 hours and more. However, the data collected showed that all of the layers reached temperatures above 4°C at the first hour. According to another study, it was found that insulated lunch bags were unable to keep cold foods below 4°C or 40°F (Wong, 2004). Additionally, according to the ANOVA analysis, there was a statistically significant (p value = 0.000000 for all layers in Table 4) difference between the chicken breast temperature in each of the three layers at the 8 hour mark. The data showed that the best layer at keeping food cold was layer 2, the next best was layer 1 and the least effective was layer 3. The middle layer was the best at keeping the chicken cold but not enough to keep food out of the danger zone.

Many factors may have influenced the outcome of the results. For example, the researcher placed the Fitness Lunch Bag on the floor during the data collection process. The floor may have increased the temperature of the bottom layer because the floor had a heated hardwood flooring system. Heat transfer from the bottom of the bag may have influenced higher than normal numbers for the bottom layer. It is important to note that many consumers who use the Fitness Lunch Bag may store the bag on the floor at work, school or their homes due to the size of the bag. In addition, the thickness of the chicken may have influenced the temperature of the chicken breasts. Each chicken breast was filleted, baked, and wrapped around a SmartButton, and tied off at each ends with two elastic bands to minimize air exposure of the measuring device by fully concealing it inside the chicken breast.

Recommendations

Consumers

Based on this study, it is recommended that users of Fitness Lunch Bag™ bags should consume their foods within 2 hours (Canadian Food Inspection System Implementation Group, 2004). Caution should be used with any type of lunch bag, insulated and/or frozen gel packed, especially with the potentially hazardous foods. It is recommended to transfer cold foods from the Fitness Lunch Bag bag to a mechanical refrigeration unit to ensure cold foods stay at 4°C and below or 40°F and below prior to foods reaching 2 hours at room temperature within the bag.

Fitness Lunch Bag company

To improve the cold holding ability of the Fitness Lunch Bag bag, two more frozen gel packs could be inserted horizontally to ensure that all sides of the three layers containing food would be kept cold. With four frozen gel packs, the bottom and the top of the bag would be protected from temperature variances. Based on the study, the researcher noticed that the bottom layer was the warmest due to the

placement of the bag on a heated floor surface. If a frozen gel pack was placed within the bottom of the bag, then the transfer of heat from the floor surface would be minimized.

Environmental Health Officers

The major role of EHOs is to educate the public regarding food safety issues. EHOs are concerned with minimizing the risk of food borne illness which can result from consuming potentially hazardous foods left out for long periods of time at room temperature. EHOs recommend that foods sitting at room temperature should be consumed within a maximum of 2 hours (Canadian Food Inspection System Implementation Group, 2004) due to fact that microorganisms double in numbers on food at every 20 minutes (Harvard Women's Health Watch, 2011).

Limitations

There are several limitations to the study. First, the study was done without a control. The purpose of control was to give a baseline mean temperature reading of the chicken breast sitting at room temperature from 1 to 8 hours in a bag that was not insulated and did not contain frozen gel packs. However, the results from previous studies measuring temperatures of insulated bags, without frozen gel packs, and non-insulated bags, with frozen gel packs, at room temperature served as the control for this study. Regardless, the mean temperatures of a control bag would have reached the danger zone just as quickly, if not faster, than the Fitness Lunch Bag temperatures with the absence of insulation and the frozen gel packs. Another limitation of the study was that the mean temperature of the chicken breasts was collected at hourly intervals. It would have been beneficial to collect the mean temperatures at minute intervals since the chicken breast reached the danger zone within the first hour. Even though we have a regression equation for each layer, the equation would be accurate for extrapolation but not accurate for interpolation for temperatures less than one hour.

Alpha and Beta Errors

For the regression and correlation analysis, the study had no alpha and beta errors because the p-values were 0.0000 (See Table 3). The power was strong with a power value (alpha level 0.05) of 1.000 at layers 1, 2 and 3. A power of 80% of more would indicate the study is powerful (Heacock, H. and Sidhu, B., 2013a).

For the ANOVA analysis, the study had no alpha or beta errors because the p-value was not greater than 0.05 (See Table 4). The power was strong with a power value (alpha level 0.05) of 1.000 at hour 8 for layers 1, 2, and 3. Thus a power of 80% of more would indicate the study is powerful (Heacock, H. and Sidhu, B., 2013a).

Future Research

The research suggests that future research could be done in the areas including:

Conduct experiment with a control Fitness Lunch Bag along with the experimental Fitness Lunch Bag. Collect data at minute intervals from time 0 to 1 hour. Store of the Fitness Lunch Bag off of heated surfaces at room temperature. Use of 4 frozen gel packs by placing 2 in the vertical position and 2 in the horizontal position. Included other brands of lunch bags that use similar insulation and frozen gel pack system to compare the effectiveness between brands. Select other potentially hazardous foods such as beef, pork, fish, or rice for experimentation. Conduct the experiment with hot foods to determine if the Fitness Lunch Bag can keep hot foods hot (60°C and above or 140°F and above) for 8 hours or more.

Conclusion

The results of the study show that the Fitness Lunch Bag™ does not have the ability to keep cold foods out of the danger zone, 4-60°C (40 – 140°F), for 8 hours and more. In addition, the bag was not capable of keeping cold foods safe at the 1 hour mark.

Competing Interest

The authors declare that they have no competing interest nor any investment in the research topic beyond the scope of this course.

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