A Comparison of the Fat Content Between Organic and Inorganic Processed Snack Foods

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Abstract

Consumers look to organic food options as healthier alternatives to their favourite snacks. However, there is not much evidence that suggests that organic foods are in fact healthier than their inorganic counterparts, especially regarding the amount of fat in these foods. The objective of this study was to compare the fat content between organic and inorganic cookies and granola bars. This was investigated by using acetone-based solvent extraction to measure the fat content in Savor Organic Chocolate Vanilla Sandwich cookies, inorganic Oreo cookies, Annie's Organic Dipped Chocolate Chip granola bars, and inorganic Quakers Dipps Chocolatey Chip granola bars. Based on the nutrition labels of these foods, we hypothesized that the organic varieties of the cookies and granola bars would have higher fat contents than the inorganic varieties. Yet, our study found no significant difference in the amount of fat between the organic Savor cookies and the inorganic Oreo cookies ($p = 0.155$), and the organic Annie's granola bars and inorganic Quakers granola bars ($p = 0.148$). These results suggest that fat may not need to be a consideration for shoppers who look to buy organic foods as 'healthier' options.

Introduction

With the ever-increasing number of food options available to consumers, choosing what to buy at the grocery store is becoming more complex. One consideration among this is the choice of whether to buy organic or inorganic foods. Organic foods differ from inorganic foods in that they are farmed or grown without the use of artificial chemicals, antibiotics, hormones, or genetically modified organisms (GMOs) (Brown, 2021). Additionally, organic foods do not contain artificial food additives (Brown, 2021). As a result of all of these factors, many consumers seem to believe that organic foods may be healthier than inorganic foods as they are more 'pure' or 'natural' (Pearson et al., 2010). In fact, the organic foods industry is a multi-billion dollar industry that is experiencing tremendous growth (Haumann, 2022), indicating the rising popularity of organic foods with consumers. The overwhelming majority of studies that have examined the matter indicate that 'health' is one of the primary reasons consumers buy organic foods (Hughner et al., 2007). A study by Petrescu and Petrescu-Mag (2015), found that 87% of organic food consumers surveyed in Romania thought that organic foods are healthier than inorganic foods.

Despite these beliefs, there is actually little scientific evidence to support claims that organic foods are healthier (Pearson et al., 2010; Williams, 2002). Most studies about the health benefits of organic foods so far have investigated the use of chemicals and pesticides or the level of nutrients within the foods (Pearson et al., 2010). There have also been studies looking at the difference in sugar content between organic and inorganic foods (Dall'Asta et al., 2020; Meadows et al., 2021). However, there seems to be a gap in the literature regarding whether fat content differs between organic and inorganic foods. In a study by Lee et al. (2013) that examined biases regarding organic food products, some participants noted that organic cookies, chips, and yogurt "taste[d] lower in fat" than their inorganic counterparts. Our study aims to address the gap in available data to determine whether organic foods are actually lower in fat than their inorganic counterparts or not.

More specifically, our study investigates whether there is a difference between fat content in organic versus inorganic processed snack foods such as cookies and granola bars. The fat values on the nutrition labels for each food product indicated that the organic foods had higher fat contents than their inorganic counterparts. Therefore, we hypothesized that the organic food varieties would have a significantly higher amount of fat upon extraction than their corresponding inorganic varieties. We believe the results of this experiment will have implications concerning whether consumers choose to purchase organic foods or not, especially if they believe that organic foods contain less fat.

Methods

Sample Preparation

The experiment was conducted using four different samples of organic and inorganic foods with the aim of determining fat concentration differences between both categories. The samples were as follows: 1a) Savor Organic Chocolate Vanilla Sandwich Cookies; 1b) Oreo Cookies; 2a) Annie's Organic Dipped Chocolate Chip Granola Bars; and 2b) Quakers Dipps Chocolatey Chip Granola Bars. A trial of the experimental procedure was also conducted using an avocado sample and a sample of the inorganic Quaker granola bar to ensure that the procedure would work (Figure 1). Approximately 30 g (10 g for each of three replicates) of each food sample were crushed up and put into 12 erlenmeyer flasks, accordingly. Crushing the samples ensured a greater surface area for the acetone to interact with the food to increase the amount of fat extraction. All of the glassware used in this experiment was collected from the lab. Each erlenmeyer flask was labeled with the replicate number, the product name, and the term, 'Extraction'. These flasks were utilized to mix the acetone and food samples for the solvent extraction cycle. A set of twelve beakers were utilized to contain the extracted acetone with fat solution. These beakers were labeled with the replicate number, the product name, and the term 'Acetone'. The weight of all the empty beakers labeled 'Acetone' was measured using a scale. Approximately 10 g of crushed food sample was added to each corresponding erlenmeyer flask by pressing tare on the scale for the empty erlenmeyer flask and adding the sample until around 10 g were reached.

Fat Extraction

Using a graduated cylinder, 20 mL of 80% acetone was poured over the food sample in the erlenmeyer flask under the fume hood. The flask was then swirled for five minutes to help extract the fat into the acetone solvent and was left for a few seconds to settle. It was then carefully strained into its corresponding beaker using a funnel and filter paper, waiting for a few minutes until there were no more drops coming out of the funnel. This extraction process was repeated again with another 20 mL of acetone to ensure that the maximum amount of fat content in the food was extracted into the acetone solvent. The beakers were then placed for 24 hours under the fume hood to allow the acetone to completely evaporate, leaving behind the fat of the food sample. This extraction process was performed for each of the three replicates for the four different food types.

Data Collection and Analysis

Once the acetone had evaporated from the beakers, they were weighed using the same scale and recorded (Supplementary Table 1). This mass was subtracted from the weight of the empty beakers labeled, 'Acetone', and a yield weight was recorded (Supplementary Table 1). The fat content in 10 grams of food sample was calculated based on the nutritional label of the food product, along with the extraction efficiency for each corresponding sample (Equation 1a; Supplementary Table 2). Sample calculations are shown below for a replicate of the inorganic Oreo cookies which contained 4.5 g of fat (saturated + trans) per 23 g of cookies (Equation 1b). These calculations were performed for each food sample and recorded (Supplementary Table 3). Data for this experiment was analyzed using R studio software by performing a paired t-test.

Equation 1a.

$$\text{Average Extraction Efficiency} = \frac{(Average\ Mass\ of\ Extracted\ Fat\ of\ 10g\ of\ food)}{(Mass\ of\ Fat\ in\ 10g\ of\ food\ via\ Nutritional\ label)}$$

Equation 1b.

Sample Calculation for Inorganic Oreo Cookies:

$$\text{Normalized Extracted Fat Mass} = \frac{(Mass\ of\ Extracted\ Fat)}{(Mass\ of\ Food\ Product)} \times 10$$

Nutrition label: 4.5 g of fat per 23 g of cookies which means 2.5 g of fat per 10 g of cookie

$$\text{Extraction Efficiency} = \frac{(Average\ Mass\ of\ Extracted\ Fat\ of\ 10g\ of\ food)}{(Mass\ of\ Fat\ in\ 10g\ of\ food\ via\ Nutritional\ label)} = \frac{1.59\ g}{2.5\ g}$$

Extraction Efficiency = 0.636 = 63.6%

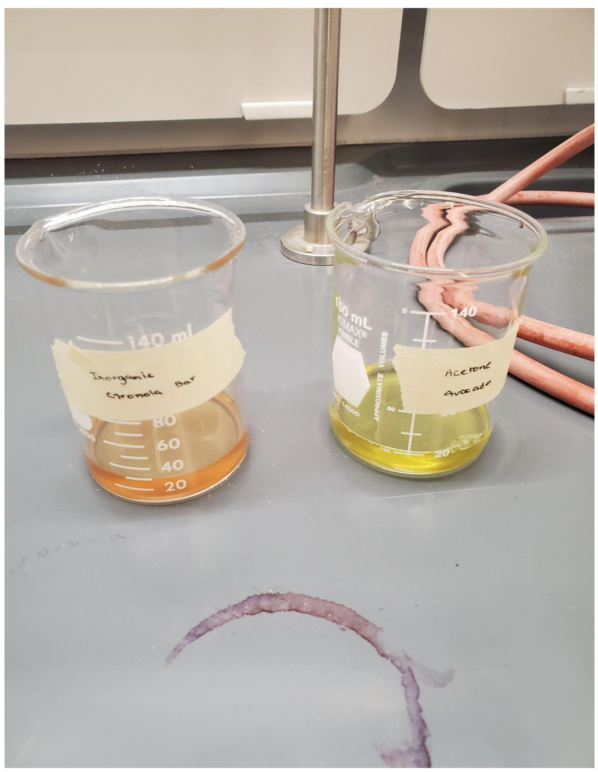

Figure 1. Beakers containing extracted mixture of acetone and fats from the trials of the procedure conducted on the avocado and Quakers inorganic granola bar samples.

Results

For each food type, the mean mass of the extracted fat was used to conduct a paired t-test to determine if there is a significant difference between the fat amount in organic and inorganic forms of the food product. For the purposes of our study, we considered a p-value of less than 0.05 as an indication of significant difference in means, and a rejection of the null hypothesis of no significant difference in means. The mean mass of fat extracted from the Savor organic cookies was 1.59 ± 0.342 g and 1.17 ± 0.181 g for Oreo inorganic cookies. There was no significant difference between the mass of fats extracted from the two different types of cookies, $t(3.03) = 1.89$ and $p = 0.155$. The mean mass of fat extracted from Annie's organic granola bars was 1.21 ± 0.274 g and Quakers inorganic granola bars was 1.56 ± 0.148 g. There was no significant difference between the mass of fats extracted from the two different types of granola bars, $t(3.07) = -1.93$ and $p = 0.148$. For both the cookies and granola bars, there is no statistically significant difference between the extracted fat mass of organic and inorganic form. This fails to reject the null hypothesis.

Of particular note, when swirling the acetone with the food samples during the extraction process, the acetone in the different replicates for each food type ended up being different colours (Figure 4). When all the acetone had evaporated from the beakers 24 hours after extraction, the organic cookie samples, inorganic granola bar samples, and organic granola bar samples all left behind fats that were brown in colour. However, the inorganic cookie samples left behind fats that were yellow in colour (Figure 5).

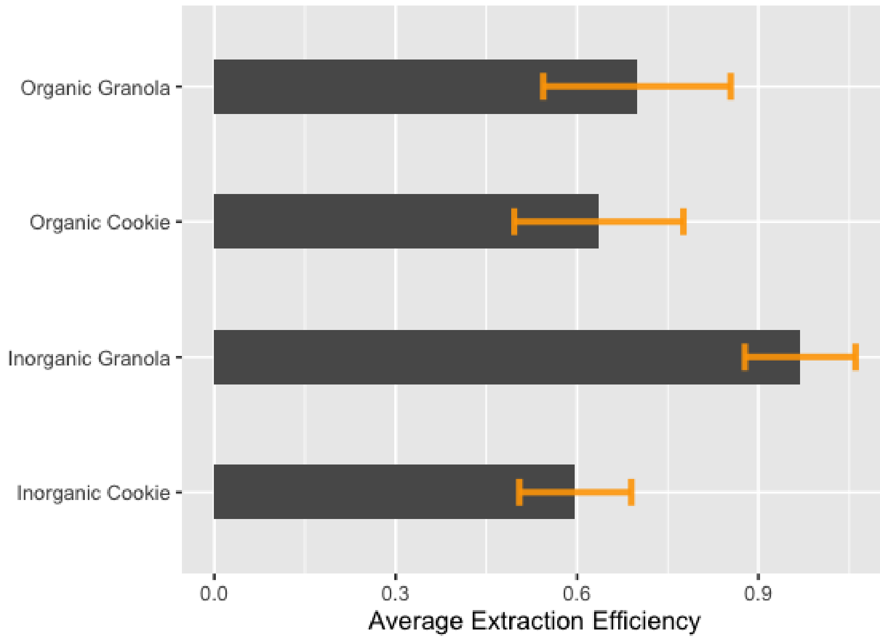

Figure 2. Bar graph of the Average Extraction Efficiency for each food type out of 1.0. The orange bars show the standard deviation of each sample group.

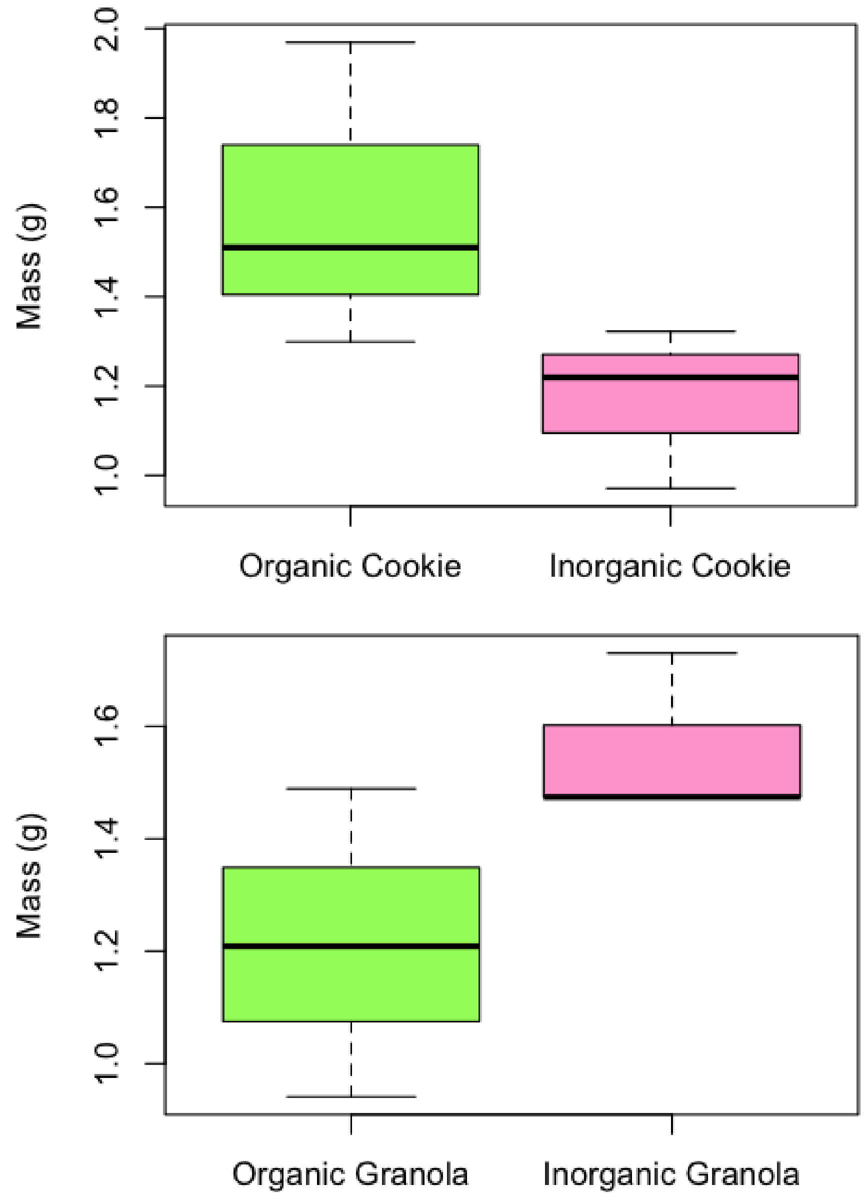

Figure 3. Box plots of the mass of fat extracted from 10 grams of each food type. Cookies (top): 1a) Organic Cookie - Savor Organic Chocolate Vanilla Sandwich Cookie; 1b) Inorganic Cookie - Oreo Cookie. Granola Bars (bottom): 2a) Organic Granola - Annie's Organic Dipped Chocolate Chip Granola Bar; 2b) Inorganic Granola - Quakers Dipps Chocolatey Chip Granola Bar. The box starts at the first quartile and ends with the third quartile of the data. The bolded lines indicate the median values. The lowest lines and uppermost lines indicate the minimum and maximum values, respectively. The inorganic granola does not have a minimum value line as the minimum value and median values coincide.

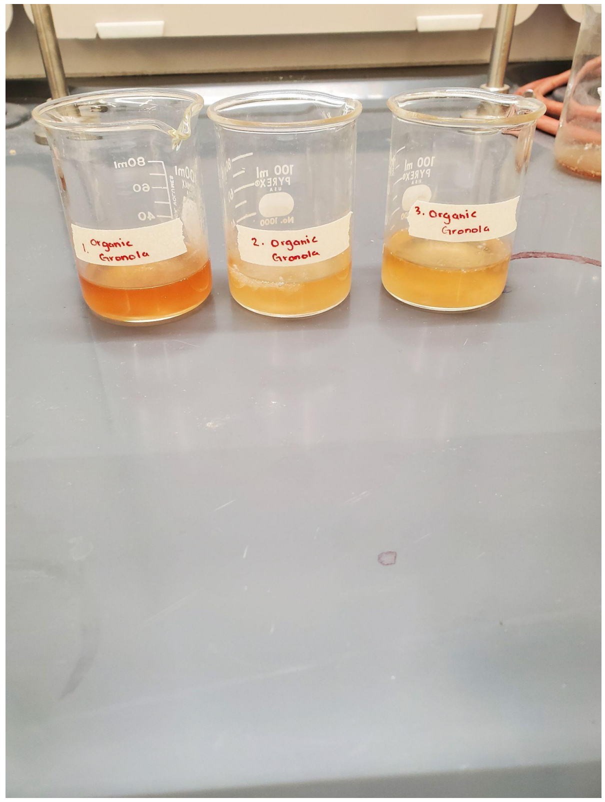

Figure 4. Acetone and fat mixture extracted from the three replicates of the Annie’s organic granola bar samples. This image shows how the mixtures are different colours despite being the same food products.

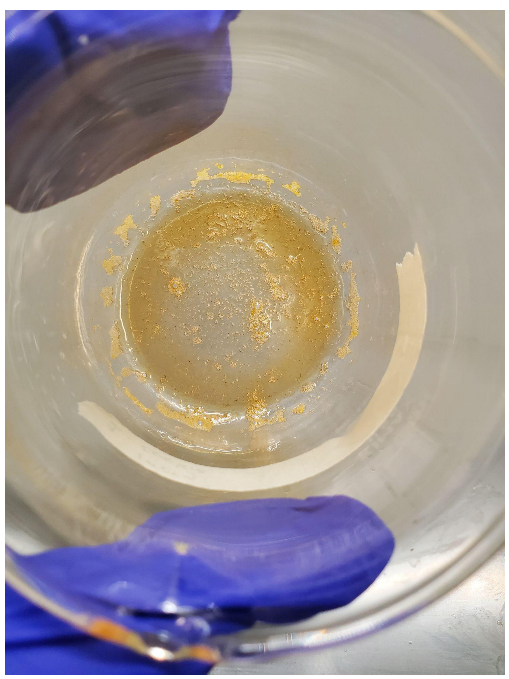

Figure 5. Fat leftover from one replicate of the inorganic Oreo cookies extraction after all acetone had evaporated. Fat is yellow in colour, which is in contrast to the brown fat observed from all other food types.

Discussion

The objective of our study was to determine whether there is a difference in the total fat content between organic and inorganic processed snack foods. Based on the analysis of the data from our study, we found that there was no significant difference in the fat content between both the organic Savor cookies and the inorganic Oreo cookies, and the organic Annie's granola bars and the inorganic Quakers granola bars (Figure 3). This finding refutes our hypothesis which stated that the organic version of each food product would have a significantly higher fat content than its inorganic counterpart, based on the nutrition labels of all tested food products.

Although there is some literature on the impact of fat content on the types of organic meat and dairy products that consumers choose (Hemmerling et al., 2015; Koistinen et al., 2013), based on our literature review, there seems to be no previous studies conducted on the difference in fat content between organic and inorganic grain-based foods. Therefore, there are no studies that we can use as comparisons to further determine the reliability of our findings.

One limit in our experiment was not being able to use the same brand when comparing the organic to the inorganic food products. Our team did try to find a brand that made both organic and inorganic snack foods, however, not many existed. The one company that did make both did not have the organic varieties in stock. Consequently, we had to use different brands for each food product. While some may argue that differences in ingredients and manufacturing processes between brands may make the results of our studies less reliable, we believe that our choice to use different brands reflects the reality that consumers face when shopping. Organic foods from the same brand are difficult to come by, yet, choosing to buy organic foods including granola bars and cookies is still a conscious decision that consumers make. When buying an organic food item, they are not necessarily checking to see if it is an organic product from the brand they like, they are just checking to see if it is an organic product. Therefore, we still believe that the results of our experiment are valid and pertinent.

There were several potential sources of errors in this experiment that may have contributed to low extraction efficiencies (Supplementary Table 2) or low accuracy in the delineation of the fat content in the various food products. One source of error could be the fact that some food samples were not crushed up as finely as others. We found that it was particularly difficult to crush up the organic cookies and granola bars. A food product sample that was less crushed up would have had less surface area for the acetone to interact with and extract the fat from. Another potential source of error was the fact that different team members swirled the Erlenmeyer flasks with the food and acetone during the extraction procedure for the different replicates. We believe that some team members may have swirled the flasks more vigorously than others leading to different rates of extraction. This was backed up by the fact that the extracted acetone and fats of different replicates of the same food product appeared to be different colours (Figure 4).

In addition to addressing the sources of error previously mentioned, there are some other steps that can also be taken in future experiments to reduce the sources of error and increase extraction efficiency. One such step is considering possible alternatives to using filter paper in future experiments. We believe that some amounts of fat may have stuck to the filter paper, not making their way into the jar with the extracted acetone and other fat, leading to a lower amount of fat recorded for each food sample. Another way of increasing extraction efficiency would be to use a mixture of two or three different solvents to increase the solubility of the different kinds of fats within the solvents (Hewavitharana et al., 2020). This is because non-polar lipids such as triacylglycerols are soluble in non-polar solvents such as hexane, while polar lipids like phospholipids are more soluble in polar solvents like acetone (Hewavitharana et al., 2020).

Conclusion

Our experiment revealed that there was no significant difference in the fat content between Savor Organic Chocolate Vanilla Sandwich Cookies and Oreo Cookies. There was also no significant difference in the fat content between Annie's Organic Dipped Chocolate Chip Granola Bars and Quakers Dipp Chocolately Chip Granola Bars. This has many implications for the debate surrounding the health benefits of organic foods, suggesting that fat is a negligible factor when consumers are considering whether to buy organic food products or their inorganic counterparts.

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Appendix

Supplementary Table 1. Table displays the raw data for the amount of food used in each sample and the amount of fat extracted from each food sample. There were three replicates (n = 3) per food type.

Food Product	Replicate #	Mass of food (g)	Mass of empty jar (g)	Mass of jar after extraction post 24 hours (g)	Fat content in food sample (jar after extraction - empty jar) (g)
Organic Cookies - Savor Organic Chocolate Vanilla Sandwich Cookies	**1**	10.362	48.877	50.442	1.565
	2	10.050	51.468	52.773	1.305
	3	10.033	68.011	69.986	1.975
Inorganic Cookies - Oreo Cookies	**1**	10.035	49.503	50.830	1.327
	2	10.467	88.465	89.481	1.016
	3	8.587	103.306	104.353	1.047
Organic Granola Bars - Annie's Organic Dipped Chocolate Chip Granola Bars	**1**	10.016	52.257	53.748	1.491
	2	10.165	49.184	50.413	1.229
	3	10.462	49.139	50.123	0.984
Inorganic Granola Bars - Quakers Dipps Chocolatey Chip Granola Bars	**1**	10.035	89.193	90.929	1.736
	2	10.192	74.788	76.290	1.502
	3	10.054	80.559	82.041	1.482

Supplementary Table 2. Average fat content (g), standard deviation (g), and extraction efficiency (%) for each food product. Values were calculated from three replicates (n = 3) per food type.

Food Product	Normalized Average Fat Content Extracted (g) *	Standard Deviation (g) **	Average Extraction efficiency (%) **
Organic Cookie - Savor	1.59	0.343	63.6
Inorganic Cookie - Oreo	1.17	0.180	59.7
Organic Granola Bar - Annie's	1.21	0.274	69.9
Inorganic Granola Bar - Quakers	1.56	0.148	96.9

** The extracted fat mass of each trial is adjusted to represent the mass of fat per 10 grams of food used.*
*** Normalized values of the extracted fat mass are used for these calculations.*

Supplementary Table 3. Table displays the statistical analysis of the results, based on the raw data.

Food Product	Replicate #	Fat content in food sample (extracted jar - empty jar) (g)	Normalized Fat Content in Food Sample	Normalized Mean Fat Content (g)	t-test P-values
Organic Cookies - Savor Organic Chocolate Vanilla Sandwich Cookies	**1**	1.565	1.510	1.59	t = 1.8879, df = 3.0303, **p-value = 0.1546** t(3.03) = 1.89 and p = 0.155
	2	1.305	1.299		
	3	1.975	1.969		
Inorganic Cookies - Oreo Cookies	**1**	1.327	1.322	1.17	
	2	1.016	0.971		

	3	1.047	1.219		
Organic Granola Bars - Annie's Organic Dipped Chocolate Chip Granola Bars	**1**	1.491	1.489	1.21	t = -1.9267, df = 3.0729, **p-value = 0.1475** t(3.07) = -1.93 and p = 0.148
	2	1.229	1.209		
	3	0.984	0.941		
Inorganic Granola Bars - Quakers Dipps Chocolatey Chip Granola Bars	**1**	1.736	1.730	1.56	
	2	1.502	1.474		
	3	1.482	1.474		