The Effects of Varying Temperatures on the Percentage Fat of French Fries Using Solvent Extraction

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ABSTRACT

Solvent extraction is often used to isolate one component of a mixture. This experiment involved using the non-polar solvent, pet ether, to extract fat from french fries baked at 325°F, 375°F, 425°F, and 475°F. Solvent extraction is based largely on polarity. Because fat is non-polar, it is attracted to petroleum ether (C6H14) and will dissolve in it. After the petroleum ether dissolves, only the fat remains. We hypothesized that as cooking temperature increased, the fat content of the fries would decrease, as a result of fat melting off of the fries and not being reabsorbed. There were no clear patterns from the data collected, possibly due to error. For future research, larger trials will be needed, preferably in the same oven to be sure that the temperatures remain the same. This would help to minimize the impact of outliers while also allowing more accurate conclusions from the data, as there is more of it.

INTRODUCTION

Solvent extraction is a method used to extract a substance from a compound through the moving of molecules between phases. In this particular experiment, we performed a solid-liquid extraction, which was used to isolate fat from french fries using the solvent, petroleum ether. The process of solvent extraction is based largely on the concepts of polarity and solubility of the compound and solvent (Richardson, 2020). Polarity is a chemical property of a substance based on the distribution of electrical charge in a molecule. Slight differences in the charges and distributions of atoms in a molecule can cause the molecule to have different charges on different ends. Additionally, solubility is the ability of a solute to dissolve in a solvent. In this investigation, the solute is fat and the solvent is petroleum ether. Primarily, polar substances are attracted to other polar substances due to their charges, as the partial negative charge attracts the partial positive charge on the other polar molecule. On the other hand, non-polar substances are attracted to other non-polar substances as they are not attracted to polar substances. Consequently, polar substances are soluble in polar substances but not soluble in non-polar substances (BYU's, 2020).

Fats are triglycerides, which are generally soluble in non-polar organic substances but insoluble in water. Triglycerides are made of three fatty acid hydrocarbon chains that are connected to a glycerol backbone and do not have any polar bonds, making them non-polar (Boston University, n.d.). Similarly, petroleum ether is non-polar as it is a solvent made of a mixture of hydrocarbons (Nichols, 2020). In this solid-liquid extraction, the fat and the petroleum ether are both non-polar substances, allowing the fat to dissolve in the petroleum ether and be separated from the rest of the french fry (Mott, n.d.).

Potatoes themselves have a low-fat concentration, but the way french fries and other potato products are cooked can result in different fat concentrations (Bordi et al., 1997). Prior to this experiment, we figured there would not be a large amount of fat in the french fries, as the nutrition facts stated the fries contained roughly 3.57% fat as seen in Figure 1, (Golden French Fries, n.d.). The experiment conducted by Uran & Gokoglu (2011) involves extracting fat from anchovies in order to see how different cooking methods change the nutritional content of the fish. Their results concluded that fat absorption rates in the anchovies decreased as the cooking temperature increased. It was also mentioned that fat does not evaporate when cooked, but fat can melt at a temperature of 130-140°F. Keeping these observations in mind, we assumed that the fat would melt off of the french fry and not be able to absorb back into it at higher temperatures. The french fries used in this experiment are initially frozen but then baked at a designated temperature and time. This experiment keeps time constant, but changes the cooking temperatures of the fries.

MATERIALS

Before performing solvent extraction on the french fries of varying temperatures, they were baked. All of the french fries were spread on a cookie sheet and placed on the middle rack of four varying ovens. The fries at 375°F were placed on the top rack and two out of the four fry temperatures placed tinfoil on top of the cookie sheet before placing them in the oven. To begin the solvent extraction process, approximately one gram of french fry was granulated using a mortar and pestle. The granulated fries were then placed into a glass vial. Next, six milliliters of petroleum ether were added to the glass vial with a graduated pipette and were shaken vigorously for one minute to effectively combine the french fry and petroleum ether. As shown in Figure 2, this mixture was left to sit for approximately twenty minutes, allowing a supernatant layer to form at the highest point of the vial, while the solids settled. Then, the mass of an empty petri dish was recorded, and a micropipette was used to remove the supernatant to the petri dish. Petroleum ether is very volatile, meaning it evaporates quickly. In order to only measure the fat in the petri dish, it was important that we waited for the pet ether to evaporate. After the petroleum ether evaporated, the petri dish was weighed to measure the mass of the petri dish and fat. By subtracting the weight of the petri dish with the fat included, by the original mass of the petri dish, we were able to calculate an exact number for how much fat was extracted. This process was repeated three times for each of the following temperatures: 325°F, 375°F, 475°F. In addition, four trials for one gram of defrosted fries were executed as a control group. After performing the trials, the fat content and the percentage of fat in the fries was calculated by determining the fat content of the french fries and dividing the amount of fat extracted by the total mass of the french fry.

PURPOSE & HYPOTHESIS

The purpose of this experiment is to determine how the temperature at which french fries are cooked affects the amount of fat a french fry contains. We hypothesized that if french fries are cooked at a higher temperature then they would contain less fat.

RESULTS

There were few distinguishable patterns in this experiment. Compared to other temperatures, the defrosted fry was reported by all four trials done to be the easiest to work with (as seen in Figure 2). This fry had a smoother, less chunky texture that allowed it to absorb and soak into the pet ether. The temperature at which the four trials were performed went up constantly with a change of fifty degrees Fahrenheit. The fat percentage shown in Figure 4 did not decrease with temperature as we suspected. At 425°F, there was the highest amount of fat. For those trials, there were multiple outliers as seen in Figure 4, most likely due to the petroleum ether not fully evaporating. The lowest temperature, 325°F, had one of the lowest fat percentages even though we hypothesized that the lower temperatures would have a higher amount of fat. At 375°F, there was a larger percentage of fat which as one of the lower temperatures, aligned with the hypothesis. However, the large gap in fat between the varying temperatures is misleading because the highest temperature, 475°F, had the lowest fat percentage of all the other temperatures.

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Nutrition Facts

About 9 servings per container
Serving size 3 oz (84g/about 7 pieces

Amount per serving
Calories 90

	% Daily Value*
Total Fat 3g	4%
Saturated Fat 0.5g	3%
Trans Fat 0g	
Cholesterol 0mg	0%
Sodium 290mg	13%
Total Carbohydrate 14g	5%
Dietary Fiber 1g	4%
Total Sugars less than 1g	
Includes 0g Added Sugars	0%
Protein 2g	
Vitamin D 0mcg	0%
Calcium 0mg	0%
Iron 0.6mg	4%
Potassium 340mg	8%

* The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

Figure 1. The nutritional facts of the Ore-ida Golden Steak Fries used in this experiment can be seen above ("Ore-Ida", 2020)

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Figure 2. Pictured above are the four glass vials with the french fries and petroleum ether mixtures; one with the defrosted fry (far left), and the other three cooked at 475 degrees fahrenheit. The supernatant layer can be seen at the top part of the solutions.

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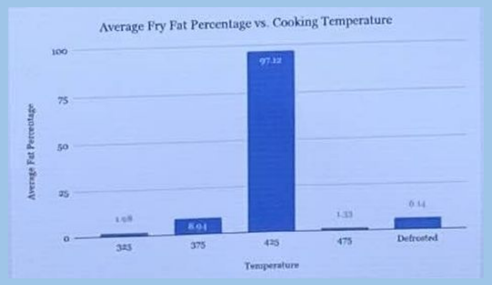

Figure 3. The data above shows the temperature the potatoes were baked at, along with the average percentages of fat. Taller bars may indicate outliers due to error.

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	Temperature (°F)	Mass of Fry (g)	Mass of Petri Dish (g)	Fat extracted (g)	Percentage Fat (%)
Trial 1	325	1.00	8.04	0.01	1.00
Trial 2		1.02	8.28	0.01	0.95
Trial 3		1.01	8.28	0.04	3.96
Average		1.01	8.20	0.02	1.98
Trial 1	375	1.00	7.89	0.07	7.00
Trial 2		1.02	7.93	0.12	11.76
Trial 3		1.00	8.11	0.08	8.00
Average		1.01	7.98	0.09	8.94
Trial 1	425	1.07	8.07	0.18	16.82*
Trial 2		1.04	8.13	1.34	128.85*
Trial 3		1.01	7.89	1.51	149.50*
Avg		1.04	8.06	1.01	97.12
Trial 1	475	1.00	8.12	0.02	2.00
Trial 2		1.00	7.76	0.01	1.00
Trial 3		1.00	7.94	0.01	1.00
Average		1.00	7.94	0.01	1.33
Trial 1	Defrosted	1.06	8.59	0.14	13.21*
Trial 2		1.01	8.61	0.03	2.97
Trial 3		1.00	7.91	0.05	5.00
Trial 4		1.00	8.32	0.03	3.00
			11.21	0.08	6.14

Figure 4. This table contains the results of all four temperatures with three trials each and the defrosted french fries with four trials. A *** indicates the possible outliers in the data.

DISCUSSION

There were few distinguishable patterns in this experiment. Compared to other temperatures, the defrosted fry was reported by all four trials done to be the easiest to work with (as seen in Figure 2). This fry had a smoother, less chunky texture that allowed it to absorb and soak into the pet ether. The temperature at which the four trials were performed went up constantly with a change of fifty degrees Fahrenheit. The fat percentage shown in Figure 4 did not decrease with temperature as we suspected. At 425°F, there was the highest amount of fat. For those trials, there were multiple outliers as seen in Figure 4, most likely due to the petroleum ether not fully evaporating. The lowest temperature, 325°F, had one of the lowest fat percentages even though we hypothesized that the lower temperatures would have a higher amount of fat. At 375°F, there was a larger percentage of fat which as one of the lower temperatures, aligned with the hypothesis. However, the large gap in fat between the varying temperatures is misleading because the highest temperature, 475°F, had the lowest fat percentage of all the other temperatures.

CONCLUSIONS

During this experiment, there were numerous causes for error that impacted the experiment and the result. One example of error in this experiment is unintentional human error, categorized as skill-based errors. The skill-based errors in this experiment are simply parts of the experiment's plan that were not performed correctly. For example, during the experiment, there would have been differences in how the french fries were ground up because different people were using the mortar and pestle for different amounts of time. Another skill-based error is measuring. During the experiment, six milliliters of petroleum ether are dropped into the vial; however, this number might not have been exactly six milliliters for everyone during each trial due to errors in reading the measurements. The equipment in the experiment could also have been a source of error. The scale used in this experiment might not have been extremely accurate with such small differences, therefore accounting for not very many precise data results. Also, the fries were not stored in a freezer after the second experiment, and were replaced with a new bag of fries. The new fries may have differed slightly from the previous since it was a new bag. As a result of conducting the experiment virtually, there were some noticeable differences in how the experiments were conducted. For example, for each temperature, a different oven was used to cook the fries which would affect the temperature the fries were cooked at due to the quality of each oven. Another error is the amount of time that the petroleum ether was set out to evaporate. The majority of the trials let the petroleum ether and fat solution sit for twenty minutes in the petri dish. On the other hand, the solutions at 325°F and 375°F sat out overnight to let the petroleum ether evaporate. If the petroleum ether didn't evaporate it would have been counted with the fat and could inflate the numbers in the table. The final error is related to how long the fries sat out after being cooked. For most of the trials, the fries were taken out of the oven, then the first test was completed. However, the second and third fry for each trial sat out longer than the first trial and would have cooled down, changing the temperature of the actual fry and its consistency. Using a thermometer to determine the temperature of the fry itself would have provided more accurate results.

The original question being researched was, "How does the temperature at which Ore-Ida french fries are cooked affect the amount of fat inside the french fry?" Some parts of the data support that when french fries are cooked at a higher temperature, they contain lower amounts of fat. However, because of the errors and the small amount of testing done in this experiment the answer is inconclusive. Nonetheless, these results provide information that could be used for future research on this topic.

For future research, we recommend that a consistent temperature is used. Additionally, while this experiment involved using the cooking temperature that the oven claimed, further experimentation may be more accurate if a consistent thermometer is used to measure the temperature within the fries after they are cooked. Along with this, more trials could be executed to find stronger averages, so that outliers do not affect the data so heavily. Performing multiple trials in the same lab would also decrease the risk of data so heavily. Performing multiple trials in the same lab would also decrease the risk of potential outliers and make the data more reliable. Also, more tests should be conducted to better determine if there is a correlation between the temperature and the amount of fat inside a french fry. Other foods could be tested for fat percentage based on temperature, to determine if they have the same results. This research could also determine whether or not all nutrition facts are actually accurate after the food is cooked. Along with this, other experiments could be done to determine if freezing foods has a similar or different effect compared to heating them. An experiment like this could be done using different solvents to extract the fat, such as acetone. Although the results from our experiment, regarding cooking temperature's effect on the fat in french fries were inconclusive, they provided information on what future research could be conducted and how it should be done.

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