Lab Report 3: Emulsions

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Kitchen 1: Marta Barys, Melinda Cates, Jennifer Reed, Adriana Salinas

Introduction

Emulsions come in many different forms, and are used in many different foods and everyday products. Emulsions are two liquids, often oil and water, that when added together do not form a homogenous mixture. When energy is added, such as shaking, one of the liquids distributes as smaller droplets into the other liquid (McClements 2016). There are two types of categories of emulsions: oil-in-water and water-in-oil. Examples of oil-in-water emulsions would be milk, salad dressings, mayonnaise, and certain sauces. In these, the oil droplets are distributed through an aqueous solution. In water-in-oil, the water is distributed through the oil, such as butter or margarine (McClements 2016). A crucial component to a stable emulsion is the addition of an emulsifying agent. An emulsifying agent has both polar and nonpolar groups, which are drawn to both aspects of the emulsion. This struggle between the groups holds the emulsion together. Different emulsifying agents can impact the type of emulsion depending on if the agent is attracted more to oil, or more to water (McWilliams 2012). One of the most useful emulsifying agents is egg yolk, since the lecithin within the egg yolk is amphiphilic. Amphiphilic means the compound contains both hydrophobic and hydrophilic ends. The hydrophobic end will attract to the oil in the mixture, while the hydrophilic end will attract to the water. The amphiphilic emulsifier, or egg yolk, makes a type of chemical bridge that disconnects and connects hydrophobic to hydrophilic (Hartings 2017). This action, as well as the yolk proteins being drawn to the spaces between the droplet creates a stable and blended emulsion (McWilliams 2012).

The stability of the emulsion is directly related to the amount of emulsifying agent used. The emulsion will be stable once enough agent is incorporated to create an entire layer around each individual droplet, and will be considered a permanent emulsion, such as mayonnaise. Once every droplet has been covered, there is no added advantage to adding more emulsifying agent. It is possible to break permanent emulsions, but that does not normally occur with proper care of the mixture (McWilliams 2012). The viscosity of an emulsion can also impact the stability. Sweeter salad dressings are an example of this. The use of a viscous sugar syrup or honey can prevent or hinder the droplets from bumping into each other more frequently, and merging together. The delay of the emulsion separating into two phases is considered a semi-permanent emulsion (McWilliams 2012). Oil and vinegar salad dressings are excellent examples of temporary emulsions. The lack of an an emulsifying agent, and the large insoluble spices, such as black pepper, mean that the droplets can readily collide with each other, and easily separate out into their two different states (McWilliams 2012).

The purpose of this experiment was to determine the difference between an oil-in-water and water-in-oil emulsion, to illustrate the use of eggs in mayonnaise or dressing, and to explain the effect shear force has on the stability and droplet size of an emulsion. Measurements of viscosity, and microscopic observations were also completed.

Materials and Methods

The experiment consisted of two different procedures. The first procedure called for the formation of a dressing with two different recipes, and the second procedure called for a butter. Half of the class made a dressing based on Formula 1 and the other half used the recipe for Formula 2. The difference between the two dressing was that Formula 1 was made with 34 grams of egg yolk, and Formula 2 was made without the egg. The rest of the ingredients were the same. A Kitchenaid stand mixer was used to mix 30 ml of vinegar, 4 grams of sugar, 3 grams of salt, 1.2 grams of dried mustard and 1.2 g of paprika (and egg yolk only for formula 1). After thirty seconds of mixing all of the ingredients, 3 ml of canola oil, which was substituted for the corn oil, was added at the time until all 236 ml of oil were used. Next, 14 ml of the dressing was transferred to a 15 ml centrifuge tubes, and left for one hour. Another 120 ml of the dressing was poured into a 50 ml beaker. To measure viscosity, a Fungilab viscometer with spindle 6 was used at 100 RPM. The test ran for one minute. The last part of this section was to mix one drop of red food coloring with one teaspoon of dressing. The obtained dressing emulsion was transferred onto the microscope slide, covered, and observed through the microscope.

The second part of the experiment made butter out of cream. 500 ml of heavy cream was whipped with a Kitchenaid hand mixer until it started to foam. The mixer was started at the slowest speed and increased gradually. To prevent any spills, the bowl was covered with cheesecloth. The cream was whipped until the liquid began to separate, and a solid was formed. A cheesecloth was used to press the solid (butter), to drain more of the water. Afterward, the butter was washed with chilled water by adding it to the bowl with the mixer at medium speed. This step was continued until the water being used to wash the butter continued to run clear. After the butter was complete, one drop of red food coloring was added to one teaspoon of the butter. A sample of the emulsion was transferred onto a slide, covered, and viewed through the microscope.

Results and Discussion

The volume (ml) of the top phase recorded after 1 hour

Sample	Kitchen 1	Kitchen 2	Kitchen 3	Kitchen 4
Tube 1	0	13.1	1.5	0
Tube 2	0	12.9	1.2	0
Tube 3	0	12.8	0.9	0
Mean	0	12.93	1.2	0

Dressing Readings by Kitchen

	Amount of creamed potion (ml)	Amount of emulsion	Percentage of creaming (%)	Viscosity	Cp (%)
Kitchen 1 *	0	15	0	1955.1	19.6
Kitchen 2	12.93	15	86.2	152.7	15
Kitchen 3	1.2	15	8	127.3	1.3
Kitchen 4 *	0	15	0	3070.1	30.7
Mean			23.55	1326.3	16.65
SD			41.94	1443.51	12.17

*dressing with egg yolk

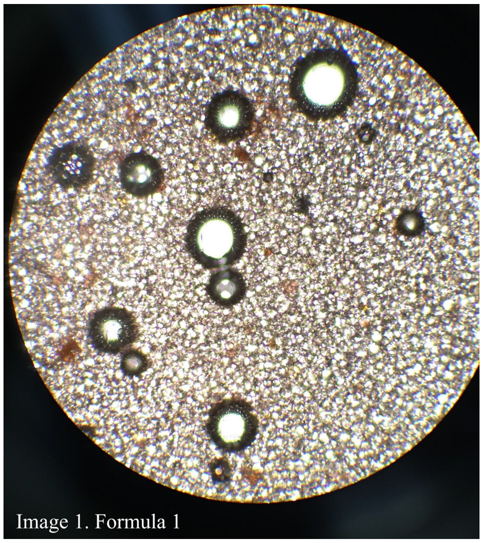


Image 1. Formula 1

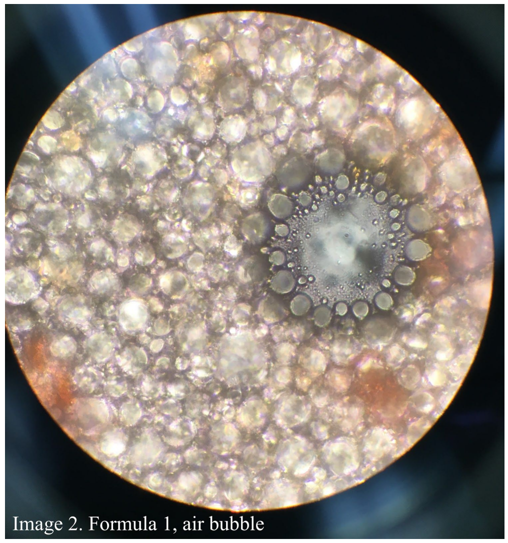


Image 2. Formula 1, air bubble

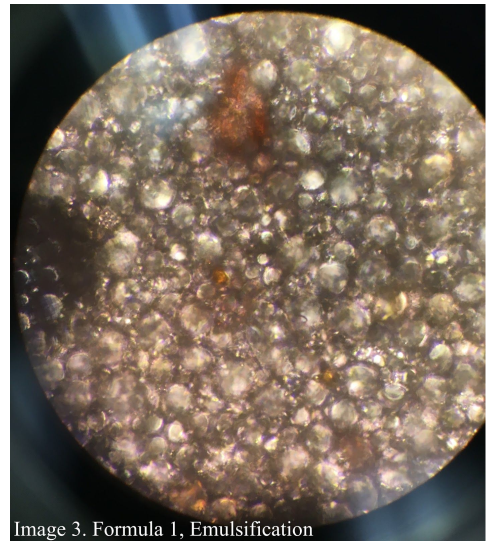


Image 3. Formula 1, Emulsification

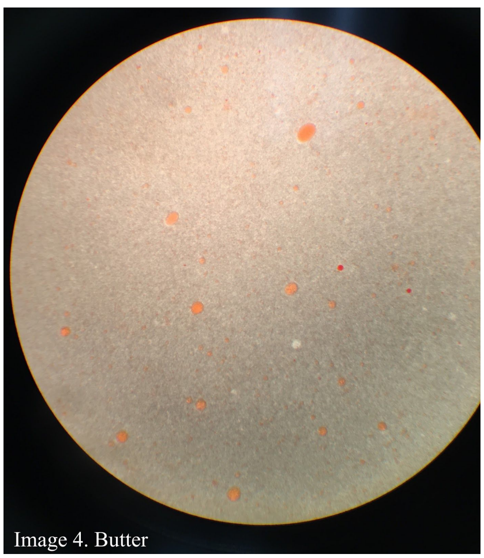
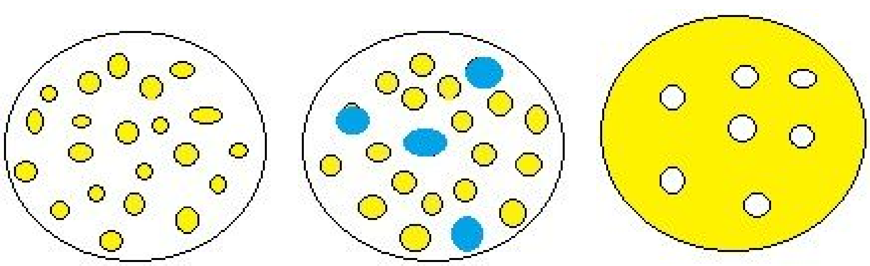


Image 4. Butter

Drawing to Question 3 of the Lab Manual



Yellow color	oil
White color	water
Blue color	air

Heavy cream   whipped cream   butter

The tubes from the kitchen one and kitchen four that contained the egg yolk did not separate, thus did not get any amount of creamed portion. This happened because the egg yolk was an emulsifier which stabilized both emulsions and prevented separation. Also, the viscosity of both kitchens was much greater compared to the kitchens that made the emulsions without the egg yolk. As shown in the microscopic images one, two and three the mixture looked homogenous with no separation. This was due to the fact that eggs were used in the formulation one dressing which emulsified the solution, preventing the separation of the aqueous and oil substances. A water soluble stain was used to show the water dispersed evenly throughout the emulsion. The drawings comparing the heavy cream, whipped cream, and butter demonstrated the the transition from an oil-in-water to a water-in-oil mixture. The cream was the oil-in-water emulsion, and butter was the water-in-oil. The structure of whipped cream contained 35-40% of fat. When the heavy cream was whipped air was added to the mixture, and the whipping continued, the fat structures began to breakdown, causing the fat globules to combine, and the buttermilk and air to be released. The butter was a water-in-oil emulsion as shown by Image 4. The red food dye was water soluble therefore it only bound to the water molecules. In Figure 4 you can see small red dots throughout the slide showing the water droplets dispersed throughout the oil that comes from the cream.

Conclusion

Emulsions can be found in a variety of everyday household goods such as salad dressings, condiments, and even butter. This emulsion lab provided a thorough understanding of different functionalities of ingredients in certain food products, and how emulsions differ from water-in-oil to oil-in-water. By identifying, for example, the purpose of eggs in mayonnaise and other dressings, it could be observed that some emulsions can take a significant amount of mixing time before the products become fully integrated. Additionally, the ability to study the emulsion droplets under a microscope, and measuring the viscosity of each said emulsion, allowed for the determination of how stable each emulsion was. The microscope observations provided further detail as to learning the difference between oil-in-water emulsion, and water-in-oil emulsion. One portion of the lab was spent creating dressing from egg yolk, vinegar, salt and sugar, dry mustard, paprika, and canola oil. This section of the lab studied the effects of using different proportions of ingredients, and how it affected viscosity and the actual emulsification process. A stained emulsion slide was viewed under a microscope, and can be referenced in images 1-3 above. Image 3 represents the final oil-in-water emulsification. The second portion of this lab made butter using only heavy whipping cream. By beating the whipping cream for approximately seventeen minutes, the liquid separated from the solid thus forming butter (the solid) and buttermilk (the liquid). When viewed under a microscope, the butter could be classified as a water-in-oil emulsion, whereas the dressing mixture was classified as an oil-in-water emulsion.

References

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McWilliams M. 2012. Sensory Evaluation. In: Vernon R. Anthony, editor. Foods Experimental Perspectives. 7th edn. New Jersey: Prentice Hall. p