FOOD SCIENCE C: EMULSIONS AND FOAMS

1. **DESCRIPTION:** Teams will use the scientific method to study food emulsions and foams, and experiment with ingredients and physical parameters to produce an oil in water emulsion model typical of those used in many types of foods, such as salad dressings, milk, cream soups and sauces.

2. **TEAM OF UP TO**: 2

3. **MAXIMUM TIME:** 50 min

4. **IMPOUND**: YES (Notebooks)

5. **TEAMS MUST PROVIDE:** Vinyl or latex gloves, safety aprons or lab coats that cover to the knee, pants or skirts that cover the legs to the ankles, closed-toed shoes and OSHA approved chemical splash goggles, a pen or pencil, and a non-programmable calculator. No notes are allowed during the event. Don't forget your notebook!

6. **EVENT LEADERS WILL PROVIDE:** Graduated cylinders, stopwatches, scales, rulers, reagents, waste containers, ALL approved ingredients in Section 11, methods for tests.

7. **THE COMPETITION:**
   a. Prior to the tournament teams must perform at least 4 experiments to understand food emulsions and foams and determine a formulation for the longest lasting emulsion. Guidelines for these experiments are located in Section 11: Experiment Guidelines.

   b. All experiment data and documentation from experiments must be recorded in a lab notebook. Never erase in a lab notebook. If a mistake is made, simply strike through the mistake with a single line, but don't white it out, erase it or scribble over it. The lab notebook will be submitted prior to the event on tournament day. The lab notebook must have a separate section for each experiment performed. If teams do 4 experiments they will have 4 experiment sections. If teams do 7 experiments there will be 7 experiment sections. The notebook's first page must show the school name and student names, and must have a Table of Contents containing Experiment Names and page numbers for each section. Each experiment section within the notebook must include the following information and will be scored as follows:
      i. Experiment Name – 2 Points
      ii. Hypothesis – 2 points
      iii. Variables:
         a. Controlled Variable(s) – 2 points
         b. Independent Variable(s) – 2 points
         c. Dependent Variable(s) – 2 points
      iv. Ingredient Information and Materials (in grams or milliliters) – 10 points
      v. Procedure – 4 points
      vi. Qualitative observations during the experiment – 8 points
      vii. Quantitative observations during the experiment (data table, graphs) – 8 points
      viii. Discussion of Results – 8 points
      ix. References – 2 points

   The lab notebook score will be determined by summing the first 3 experiment section scores and the final experiment section score given in the notebook. Maximum score for each section is 50 points. The maximum notebook score is 200 points. This score will be worth 40% of the event. Teams will impound their

notebooks prior to the event.

c. The final experiment(s) allow teams to use any of the ingredients from the approved list and team selected methods to determine a formula for the longest lasting emulsion.
    i. Teams may use any combination of ingredients from the approved list; however, the emulsion must contain 90 milliliters of water and 10 milliliters of oil. The total combination of water, oil, and other ingredients must not exceed 103 milliliters.
    ii. Emulsion stability will be measured by vigorously shaking the emulsion for 20 seconds in a closed (sealable) container, then pouring it into a 100 milliliter graduated cylinder for observation at room temperature.
    iii. The emulsion will be timed (in seconds) until 3 milliliters of oil has separated (destabilization). Longest time to destabilize out of all the teams will receive 150 pts, and that time will be set as 100% of score.

d. Teams will have a MAXIMUM of 50 minutes during the event to perform tasks and laboratory experiments related to emulsion chemistry, such as those listed in 8a-e.

8. **SAMPLE TASKS AND LABORATORY EXPERIMENTS**:
    a. When given unknown samples of oils, teams will use melting point and density to identify the oils.

    b. When given emulsifier, teams will identify as protein, carbohydrate, polysaccharide or lipid/phospholipid using the Biuret, Benedicts, Iodine or Sudan IV test.

    c. When given emulsion stability data, teams will calculate rates of phase separation.

    d. When shown micrographs, drawings or food items, teams will identify as emulsion or foam, whether stable or unstable, and type of emulsion or foam (O/W, W/O, Air/W, Air/O.).

    e. When given chemical structures of emulsifiers, team will identify the emulsifier.

9. **SCORING:** The team with the highest overall score is the winner. Scoring for each parameter is as follows: Notebook: 40% (200 pts); Emulsion Stability: 30% (150 pts); Tasks and Experiments: 30% (150 pts). The maximum score for the event is 500 points.

10. **REFERENCES**:
    Event-specific information:
    http://www.cals.ncsu.edu/foodrheology/fsso/sciolym.html

    Other helpful articles:
    http://www.scientificpsychic.com/fitness/fattyacids1.html
    http://www.uark.edu/depts/foodsci/mystery/manual/08_missingyolk.html
    http://chestofbooks.com/food/science/Experimental-Cookery/Some-Food-Emulsions.html
    http://www.ifr.ac.uk/Materials/fractures/emulsions.html
    http://www.popsci.com/diy/article/2008-10/xanthan-gum-or-my-first-hydrocolloid
    http://www.foodproductdesign.com/articles/2007/06/x-is-for-xanthan-gum.aspx
    http://findarticles.com/p/articles/mi_m3289/is_n5_v159/ai_9229355/

    Lab notebook:
    www.sciencebuddies.com/science-fair-projects/project-laboratory-notebook.pdf
    http://www.colorado.edu/MCDB/MCDB3140/notebooks.html

11. **EXPERIMENT GUIDELINES:**

The following materials will be needed for all experiments:

- Goggles, gloves, and lab coats must be worn during any and all experiments.
- Colored Water – mix 1 liter of tap water in a non-staining pitcher or flask with 1 packet of sugarless powdered drink mix (red, green, purple, or blue) and stir.
- Oils
- Teams can request supply packets containing enough Polysorbate (Tween) 20, whey protein concentrate and xanthan gum for at least 3 experiments. These requests should be sent via email to Sharon Ramsey (ncsofoodscience@gmail.com).
- For all experiments prior to the event, the team must provide all other ingredients needed from the Approved Ingredient list that follows.
- Product name, nutrition information, and food storage or food safety information for all ingredients used must be recorded in the notebook in the materials section for each experiment.

Approved Ingredients:

Vegetable Oil (10 milliliters)
Peanut Oil (10 milliliters)
Olive Oil (10 milliliters)
Corn Oil (10 milliliters)
Canola Oil (10 milliliters)
Water- may vary temperature (90 milliliters)
Lemon Juice (up to 3 milliliters)
Milk (up to 3 milliliters) or Dried Milk Powder (up to 2.0 grams)
Whey Concentrate (up to 2.0 grams)**
Egg White, fresh (up to 3 milliliters)
Whole Egg (up to 3 milliliters)
EggYolk (up to 3 milliliters)
Table Salt (up to 3.0 grams)
Xanthan Gum Powder (up to 0.25 grams)**
Polysorbate 20 (AKA Tween 20)(up to 3 milliliters)**
Vinegar
All-Purpose Flour (up to 2.0 grams)
Corn Starch (up to 1.0 grams)**
Ascorbic Acid (ex. Fruit Fresh®)(up to 0.25 grams)

*** supplied by NC State upon request. Send requests to: ncsofoodscience@gmail.com*

Experiment 1 – Effect of emulsifiers on emulsion stability

Materials:

For each test, you will use:

- 90 milliliters colored water
- 10 milliliters vegetable oil
- Sealable container that will hold at least 200 milliliters (empty soft drink bottle, plastic GladWare with sealable lid, etc.)
- 1 clear 100 milliliter graduated cylinder for water and emulsion, clean and dry
- Stopwatch
- Other ingredients as shown in table on the next page:

Emulsion Trial	Water (mL)	Oil (mL)	Other Ingredient
1	90	10	None - Control
2	90	10	2.0 grams sucrose
3	90	10	2.0 grams whey protein concentrate
4	90	10	0.25 grams xanthan gum
5	90	10	3 milliliters Polysorbate 20 (Tween 20)
6	90	10	3 milliliters egg yolk (fresh)*

*separate egg white and yolk into two dishes or sample containers. Keep refrigerated.

Procedure:

1. Measure 90 milliliters of room temperature water and pour into sealable container.
2. Add "Other Ingredient" and shake or use whisk to stir until incorporated.
3. Measure 10 milliliters of oil and add to sealable container.
4. Seal container and shake vigorously for 20 seconds.
5. Immediately pour the emulsion into a clean, dry 100 milliliter graduated cylinder. If emulsion is over 103 milliliters, the team will receive 0 points for the emulsion stability score.
6. Timing will begin when the team as soon as the team finishes pouring and sets down the container.
7. Observe the emulsion stability (degree of phase separation as shown by a growing oil phase on the top) at 0, 2, 5, 10 and 15 minutes by recording the volume of the lipid phase in a data table.
8. Wash all containers with soap and warm water to remove all residue.

Record Data:

1. Qualitative observations during the experiment
2. Quantitative observations during the experiment

Results:

1. Prepare a data table showing the change in volume of oil phase (milliliters of oil on top of emulsion) as time increases for each emulsion trial.
2. Make a graph from your data tables that shows all 6 emulsion trials. Plot *Volume of Oil Phase* (y) vs. *Time* (x).
3. Calculate the *rate of phase separation* as (Δmilliliters/ΔTime)

Discussion:

1. Which is most stable? Why?
2. Which is least stable? Why?

Experiment 2

Using the method from Experiment 1, choose one emulsifier from Experiment 1 and design an experiment to test the effect of temperature on emulsion stability. Graph and discuss results as in Experiment 1.

Experiment 3

Choose only from the protein-containing ingredients from the Approved Ingredients list and design an experiment to test the effect of method of emulsion or foam formation on emulsion stability. Use the method from Experiment 1 but instead of hand shaking, teams may use electrical appliances such as blenders, mixers, as well as whisks, spoons, shaking, etc. Graph and discuss results as in Experiment 1.

Final Experiment(s)

Using any of the ingredients from the approved list, use your knowledge of the ingredients and formulate the longest lasting emulsion possible. Choose variables used in previous experiments or use new variables. Use the methods, graph and discuss results as in the previous experiments. At the event, all emulsions will be observed at room temperature.