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ABSTRACT

This booklet presents 18 experiments in the chemistry of food, suitable for elementary and secondary school science classes. Experiments deal with an analysis of milk, determinations of the amounts of sulfur dioxide, iron, and fat in foods, and the concentration of vitamin C in fruit juice and iodine in salt. Tests are provided for fats, carbohydrates, sugars, starches and proteins in various foods, and the presence of calcium propionate in bread. Other experiments include the identification of colors in food and factors involved in the discoloration of fresh fruit, the conversion of molasses into granulated sugar, the recovery of iodine from seaweed and caffeine from tea, and investigations relating to toasting bread and popping corn. (JR)

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EXPERIMENTS IN THE CHEMISTRY OF FOOD

Elbert C. Weaver
Sterling Chemistry Laboratory, Yale

Our publication "Good Morning, Your Breakfast Chemicals"[1] lists in the form of a menu chemicals naturally occuring in a typical breakfast. Numerous consumers and educators have reacted, "I'll never eat again!" Others, "Really, everything IS chemical." Finally, the suggestion which motivated this booklet, "Why don't you give us some simple chemical tests for foods?"

"Exactly what we need," was the reaction of the Consumer Information Subcommittee and many educators. Our Education Activities Committee commissioned its Senior Education Adviser, Elbert C. Weaver, to write the manual. No stranger to most of you, the author brought to this task his vast experience as a secondary school teacher and as an author of other texts. He presents these 18 experiments in the spirit of his three volumes of MCA-sponsored open-ended experiments.[2] He risks excursions into areas where there are no fixed answers and in which the student or teacher might be forced to improvise and ask further questions.

The author directs the experiments to no specific audience. The "Estimation of Vitamin C" is intriguing for a high school chemistry, biology or home economics class or laboratory. Some might perform this experiment in their homes to determine the degradation of vitamin C when, for example, grapefruit or orange juice is exposed to air. "What Makes Popcorn Pop?" will add a note of mystery and suspense as a demonstration in an elementary school science class. The experiment on "Milk" might interest the "weight watcher" to compare the mineral content of whole and skimmed milk. Other applications for this limited prepublication edition will be determined by the ingenuity of you, the reader and experimenter.

This booklet is scheduled for publication next year. Your comments and suggestions will guide us in the preparation of the final text.

April, 1973

Dr. Robert E. Varnerin
Manager of Education

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[1] MCA's Consumer Information publication. Single copy free.

[2] Available from Holt, Rinehart and Winston, Inc., 383 Madison Ave., New York, N.Y. 10017.

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MILK

INTRODUCTION

The widely used commodity, milk, is one of the most extensively processed natural foods. Early in the story of keeping cows, farmers knew that some cows gave more milk than others. This was no amazing discovery: even the Chinese early found out that one horse could run faster than another. Back on the farm, however, farmers suspected that some milk had higher butterfat content than others. This suspicion was confirmed when the cream separator was put into wide use and then farmers sold their milk on the basis of its butterfat content.

At the same time, an assumption was questioned. Were all cows healthy? Could disease be transferred through milk from an infected cow to the milk user? Also, could milk, an ideal breeding ground for all sorts of bacteria, hang around a farm while it was still warm and develop a tremendous growth load of unwanted bacteria? Both of these conditions were found to be the cause of sickness and even of death to some milk users.

A way to reduce the bacteria to a safe level was found by Louis Pasteur (1822-1895). The milk was heated to a temperature of 143° F (61.7° C) for a period of 30 minutes. Later a faster process of heating the milk to 161° F (71.7° C) for 15 seconds was shown to be equally satisfactory. Today practically all milk offered for sale is pasteurized. Most people in the United States have never used unpasteurized milk.

Did this widespread processing come without a struggle? No, indeed. "I'll have my milk just as old Bossy produces it. None of this factory business for my milk," represented a forceful school of thought. Others felt that pasteurization could be accomplished easier by means of a few drops of formaldehyde, a bacteria killer. Formaldehyde in milk is a poor combination, especially for infants.

Health officials patiently collected evidence and made a convincing case. Today practically all places require pasteurized milk by public-health regulations. Milk samples are collected at dairy farms; bacteria count and other information are sent back to the farm.

PURPOSE

The object of this experiment is to find out whether or not processing milk has any influence on the amount of mineral matter, essentially calcium, a bone-building mineral, found in milk.

Resynthesized standard 3 or 4 percent butterfat, family milk (also homogenized and pasteurized) is compared to skim milk in mineral content. For those to whom whole milk directly from a cow is available, use the unprocessed milk instead of skim milk.

MATERIALS NEEDED

Samples of milk; crucible, size 00 or larger; bunsen burner; support for crucible; balance; tongs; wire screen.

WHAT TO DO

1. Heat a crucible. This heating removes moisture and volatile materials. Cool the crucible on a wire screen or in a desiccator.

2. Weigh the crucible.

3. Fill the crucible about one-third full of family milk and weigh it again.

4. Heat the crucible until all the liquid disappears and a white ash (mineral matter) is left. Boil the milk gently at first. If the milk tends to boil too fast, apply the flame gently to the top of the crucible. The milk residue becomes brown, decomposes, and leaves a black material. Continued heating burns the black residue and leaves white ashes.

5. Cool the crucible as in step #1 until it is cool enough to be weighed and then weigh it with the residue of mineral matter it contains.

6. Calculate percentage of mineral matter.

7. Repeat steps 1 through 6 or carry them on at the same time but use skim milk.

DATA

	Family Milk	Skim Milk
1. Mass of crucible and milk sample		
2. Mass of crucible alone		
3. Mass of milk		
4. Mass of crucible and mineral matter		
5. Mass of mineral matter		
6. Percent of mineral matter		

CONCLUSION

1. Do you find any significant difference in the results?

2. What tentative conclusion may be drawn from the experiment?

EXTENSION

Use evaporated milk from a can. Add water as suggested on the label to make the evaporated milk become equivalent to whole milk.

Use this reconstituted milk as a sample to compare with fresh milk in respect to mineral matter.

What assumption was made when water was added?

Tell two ways to avoid error introduced by adding the water. Use one of them in your experiment.

Use condensed milk.

Use goat's milk or milk from another animal.

For those interested in microbiology: view on a microscope slide with magnification, diluted (with water) fresh milk vs. pasteurized milk, cold milk compared to warm milk, old pasteurized milk vs. recently pasteurized, very old vs. recent, etc. Make meaningful comparisons.

SULFUR DIOXIDE IN FOODS

INTRODUCTION

Sulfur dioxide has long been used as a preservative (fungicide) on dried fruit. It may also act as a bleach in some uses. Brown shellac becomes white shellac when bleached with sulfur dioxide. White raisins, however, reflect the color of the grapes from which they were made, and the raisins, white or dark, may be treated with sulfur dioxide in order that they will reach the consumer in good condition, not as a moldy mess. Apricots, peaches, pears and figs also may be preserved by the use of sulfur dioxide.

OBJECT

To detect the sulfur dioxide used in preserving a dried fruit and to estimate its amount.

MATERIALS

Dried fruit sample which has the words "Preserved with Sulfur Dioxide" or similar words on the label of the package; balance; filtering equipment; distilled water, 3-M barium chloride ($BaCl_2$) solution; 3% hydrogen peroxide (H_2O_2).

PROCEDURE

1. Weigh the samples just as they come from the package. Three or four small apricots or two large ones are suggested, and a corresponding quantity of other dried fruit.

2. Place the fruit in a beaker and cover it with distilled water. Stir frequently, and allow about ten minutes for leaching. The dried fruit swells, of course. Add enough water to restore the original volume.

3. Transfer the liquid and the fruit to a prepared funnel. Use a stirring rod or spatula to prevent splashing in the transfer. The solution contains the sulfur dioxide as well as sugar and other compounds leached from the fruit.

4. Add hydrogen peroxide in order to oxidize the solution of sulfur dioxide. Other materials leached from the fruit may also be oxidized so enough hydrogen peroxide should be added.

$$SO_3^{--} + H_2O_2 \longrightarrow SO_4^{--} + H_2O$$

5. To the filtrate, add barium chloride solution until precipitation stops.

6. Weigh the filter paper (or use the mass supplied on the box). Use a filter paper that has fine pores and prepare to filter. Transfer the liquid and the precipitate to this filter paper (small Buchner funnel suggested). Wash the precipitate with water. Dry the filter paper and precipitate until no change in mass is noticed on reweighing.

Find the mass of the precipitate by subtraction.

7. Calculate the ratio $SO_2/BaSO_4$ from the atomic masses. Using this ratio and the mass of $BaSO_4$, find the mass of SO_2 captured by the leaching process.

Use the mass of SO_2 and the mass of the original fruit to find the mass percentage of SO_2 used.

Change the mass of SO_2 to liters at 760 torr and 25° C. Then calculate the liters of SO_2 obtained per kilogram of fruit.

PROBE

Prunes, formerly preserved by SO_2, may now have ascorbic acid on them. What properties do the two preservatives have in common? What advantage(s) has ascorbic acid?

ESTIMATION OF VITAMIN C

DISCUSSION

A TV announcer, advertising a well-known brand of orange juice, reported its vitamin-C content to be "all natural; nothing artificial added." The same could be truthfully said about a mixture of water, citric acid, orange-peel oil, orange flavoring, and synthetic vitamin C. This mixture contains nothing artificial. It is all the real thing. The synthetic vitamin C, for example, added to the mixture is identical in its action in the body to vitamin C from citrus fruit or any other source. Some advertising tries to convey that natural materials are better (for what?) and that synthetic products are artificial and inferior. The truth is that synthetic products are identical with the natural in composition. In fact synthetic products are uniform and reliable, not the irregular mixture often supplied by nature.

A case in point is natural gas, a popular fuel. The demand for natural gas is so great that technology has been developed to produce fuel gas equivalent to natural gas. While in this case the gases present in the two mixtures differ somewhat, they both burn and release about the same number of heat units.

OBJECT

To estimate the amount of vitamin C present in a sample such as a vitamin tablet or in fruit juice.

STRATEGY

Vitamin C reacts with iodine in solution. One drop of iodine more than needed for the reaction turns starch blue. The iodine is titrated until the blue end-point is reached.

APPARATUS AND SUPPLIES

Flasks, 250 ml erlenmeyer, jars, beakers as needed; set-up for titration; starch solution; dil HCl; a large supply of iodine solution, 0.60 g/liter of iodine (dissolve the weighed iodine in a flask and then mix it with enough water to bring the volume to one liter. Be sure to weigh the iodine carefully and use 95% ethanol to dissolve it. Then add distilled water to make the volume become one liter); sample to be tested. Medicine droppers or pipets.

Caution: Avoid getting iodine on the fingers. A brown stain forms. A solution of sodium thiosulfate (hypo), rubbed onto the brown spot helps remove it.

WHAT TO DO

Assume that the iodine solution is "standard" at 0.60 g per liter. Solid samples to be tested for vitamin content are weighed, mashed in a mortar with a pestle, and washed with distilled water into a vessel. Liquid samples may be measured and used directly, or a known volume of distilled water added. Add two drops of dilute HCl to the sample and mix it thoroughly. Also add two medicine-droppers full of starch indicator.

Titrate the sample with iodine solution until a purple or violet color persists. Repeat the titration for checking. If a large difference per ml of sample is found, run a third titration.

SAMPLES

Fresh-fruit juices, canned juice, frozen juice, vitamin-C tablets, vitamin mixture tablets, canned beverages such as HiC®, mixtures of powders to be added to water to make a beverage such as Kool-Aid®, are the sorts of materials that can be tested. Filter out pulp, if necessary, and wash filtrate with a known volume of distilled water.

REFERENCE

See experiment titled "Estimation of Vitamin C in Fruit Juices" in Scientific Experiments in Chemistry--MCA, Holt, Rinehart and Winston, 383 Madison Avenue, New York, N Y 10017, for a more detailed discussion.

LIMITATION

Vitamin C reacts with elementary iodine in solution, but other materials may be present which also react with iodine. Results, therefore, should be interpreted cautiously.

EXTENSION

Sodium 2, 6-dichlorobenzenone (indophenol) in solution with phosphoric acid and glacial acetic acid to avoid interference with iron gives more reliable results than iodine alone for finding the vitamin-C content of citrus fruit juices.

Among other samples that may be tested are milk, juice from rose pips, juice from green peppers.

DISCOLORATION OF FRESH FRUIT

PURPOSE

Apples, bananas, and other fruits darken when exposed to air. This experiment is to learn about the cause of the darkening and to learn how the darkening may be retarded.

MATERIALS NEEDED

Sample of fruit, especially apple, cut fresh when all solutions are ready and in numbered test tubes. The pieces of apple should be sliced thin and made narrow enough to fit within the test tubes that are used. Test tube rack with six or more clean tubes. Supply of stoppers to fit tubes. Boiled tap water which is stored in a bottle completely full of water. Most of the dissolved oxygen has been driven out of this water. Ascorbic acid or vitamin C pills in two or more concentrations 10 g in 500 ml of distilled water is suggested as one concentration. Other concentrations can be made by using 10 ml of this solution and 90 ml of water, a dilution factor of 0.1.

WHAT TO DO

Set up a rack of test tubes with solutions ready for the apple slices. Let's find out if oxygen in the air is a factor.

Tube 1: Apple slice open to air—no liquid.

Tube 2: Apple slice and the tube closed so a limited supply of oxygen is available—no liquid.

Tube 3: Cover the slice with tap water.

Tube 4: Cover the slice and fill the tube with water that has been boiled to rid it of most of the dissolved oxygen. Close this tube with as little air as possible above the water.

Notice that a decreasing amount of oxygen is available in tubes 1 through 4.

Tube 5: Cover the slice with ascorbic acid solution (or with a solution of a crushed vitamin-C tablet).

Tube 6: Cover the slice with another concentration of the solution used in tube 5.

Tube 7 and others:

Cover the slice with equal volumes of known sources of vitamin C such as orange juice (canned, fresh, frozen), grapefruit juice, papaya juice, green-pepper juice, tomato juice, canned beverage such as Hi-C® which is marked on label "Vitamin C added."

OBSERVATIONS

Use the discoloration rate of the contents of tube 1 as a standard. Compare all the others with tube 1, as well as with each other. Make a written tabulation.

QUESTIONS

1. Is the presence of oxygen a factor in discoloring fresh fruit?

2. Ascorbic acid is a mild reducing agent. Could another mild reducing agent be used to retard darkening, a dilute solution of sulfur dioxide, for example, or benzaldehyde?

3. What causes fruit to discolor? If it is enzyme action, what can be done to retard or completely stop the enzyme action? Try it. No guarantee that you'll like it or the results.

4. Is any difference noted in the two concentrations of ascorbic acid (or vitamin C tablet solution). If not, use further dilution (or strengthening) until a difference is noted. Comment about the least amount of vitamin C which produces the effect of very little, if any, discoloration.

5. Is any difference noted between vitamin C from natural sources and vitamin C made synthetically?

INDENTIFICATION OF COLORS IN FOOD

DISCUSSION

We love to see the bright orange color of ice-cold orange soda, but we know quite well that no oranges that grow give that brilliant color to orangeade. Colors are added to many foods and beverages to make them more attractive. The green in the frosting of a St. Patrick's-Day cake is made by adding a bit of green dye, but the green carnation was made by letting it soak some ammonia water up through its stem.

While we adore colored TV sometimes, at least as a technical accomplishment, enjoy colored pictures in books and magazines, and we get and increasing color splash in our clothing, color in foods is a different matter. The coloring matter added to foods must be safe and the amount of it limited. Certain dyes called FD&C (refers to Food, Drug, and Cosmetic Act, 1960) colors are permitted. Samples of each color may be obtained by purchase from a local food store—egg dyes, perhaps, or vials of food-coloring dyes, or from:

H. Kohnstamm and Company, Inc.
Attn: General Sales Manager
161 Avenue of the Americas
New York, NY 10013

or from:

National Aniline Division
Product Manager-Certified Colors
and Food Acids
Allied Chemical Corporation
40 Rector Street
New York, NY 10006

MATERIALS NEEDED

Bottle of orange soda water, two 500-ml beakers, piece of white wool cloth about 10 cm square (size or shape not important), tongs, Amberlite LA-2 resin (made by Rohm and Haas, Independence Mall West, Philadelphia, PA 19105) available through laboratory suppliers, n-butyl alcohol (C_4H_9OH), hexane (C_6H_{14}), saturated solution of ammonium sulfate [$(NH_4)_2SO_4$], blue litmus, 1% solution of sodium chloride ($NaCl$), 0.1% solutions of FD&C colors red and yellow separately. Other colors if necessary, 10% NH_3 (aq) solution (at 20°C, saturated ammonia water is 33.1% NH_3 by mass).

Filter or chromatograph paper, Whatman No. 1; capillary tube made by drawing 6-mm soft glass tubing to as long a tube as can be made by use of a bunsen burner and wing top. (Hazard to eyes and hands. Protect eyes. Dispose of unwanted capillary glass tubing properly.) Several screw-cap jars or open jars that can be covered. Small cake of soap. Small beakers, 500-ml separatory funnel.

WHAT TO DO

1. Pour all but 25 ml of the soda into the 500-ml beaker. Immerse the wool cloth in the soda and bring the mixture to a boil and continue boiling for about three minutes. Stir. Notice that CO_2 escapes from the liquid.

2. Use the tongs to transfer the piece of cloth to another 500-ml beaker which is one-half full of tap water. Rinse several times until the rinse water is clear.

3. Compare the color of the cloth with the color of the soda after the cloth has been removed.

4. Use a mild soap and wash the colored cloth gently. Does the color wash out? To what extent?

5. An extension or alternate experiment is suggested. Use cotton instead of wool. Repeat the same procedure. Make a second trial (more soda water needed) but mordant the cotton so that the dye becomes anchored. Look up the process of mordanting.

6. Make a 10-percent solution of Amberlite Resin LA-2 in n-butyl alcohol.

7. Add 10 ml of the solution made in part 6 to the remaining 25 ml of orange soda water in a separatory funnel. Shake gently until the color leaves the water layer. (If shaking is too vigorous and an emulsion forms, add a drop of ammonium sulfate [illegible])

8. Draw off the lower water layer and save only the upper butyl alcohol-resin layer.

Wash the solution in the separatory funnel three times with 10 ml of water, shaking gently after each washing until blue litmus shows that no acid is present.

9. Now add 20 ml of hexane to dissolve the dye. The dye is now in a mixture of n-butyl alcohol and hexane. Add 9-ml portion of ten percent ammonium hydroxide. Shake gently and recover the lower ammonia-water layer. Do this twice more and put all the dye solution from the separatory funnel together in a small vessel.

10. Cut a chromatograph paper a little longer than the height of the jar, about 20 cm. Rule pencil lines across the paper about 1.5 cm from both ends. Prepare to suspend the chromatograph paper strip from the cover of the jar, or perhaps over the upper edge.

11. Put one percent sodium chloride solution in the jar to a depth about one-half way to the lower pencil line. Put a drop of the dye solution from part 7 onto the paper on the line, using the small capillary tube in the transfer. Cover the jar to maintain a saturated vapor.

12. In another identical jar and chromatograph paper strip, use a FD&C orange dye (or a red and a yellow FD&C dye of a mixture is suspected by two spots separating in part 9).

13. After a given time, the same for the known and unknown chromatograph to form by climbing up the paper by capillary action, measure the R_f (rate of flow) for both.

14. A set of standards may be established for known FD&C dyes. Relative R_f values for some of them are

FD&C	Blue No. 1	13.2
FD&C	Green No. 3	12.2
FD&C	Violet No. 1	0.3
FD&C	Red No. 2	2.7
FD&C	Red No. 3	0.4
FD&C	Red No. 4	1.3
FD&C	Yellow No. 5	7.3
FD&C	Yellow No. 6	4.9

If Whatman No. 1 paper is too slow, No. 2 was 1.5 times faster in one experiment, and No. 4 was four times faster.

ACKNOWLEDGEMENT

The chromatographic part of this experiment was adapted from "Identity of Synthetic Colors in Food." Publication No. 57, FDA's Science Project Series, U. S. Department of Health, Education and Welfare.

EXTENSION

This publication suggests gelatin, candy-coated chewing gum (gum-ball machine), and hard candy as sources of FD&C colors.

As a project, try to extract and identify the dye used in "color-added" oranges. A food blender is suggested as a means of macerating the orange peels.

MOLASSES TO GRANULATED SUGAR

This is a directionless experiment. The object is to start with blackstrap molasses and end with clear crystals of table sugar (sucrose, $C_{12}H_{22}O_{11}$). For the less adventurous, start with dark-brown sugar. Sissies can start with light-brown sugar.

Read how the refining of sugar is accomplished, ton after ton, every day. Expressions such as bone-black, vacuum evaporation, crystallization, centrifuging and others may be met.

Weigh everything.

You're on your own.

IODINE IN SALT

INTRODUCTION

Common salt, sodium chloride (NaCl), usually contains some magnesium chloride ($MgCl_2$) and calcium chloride ($CaCl_2$). These impurities are not harmful to humans. In fact, calcium is needed to build bones and teeth. The two impurities, however, are hygroscopic, and the moisture they gather from the air makes common salt difficult to use in a salt shaker in damp weather.

What is done about it? Read the label on a box of free-running salt. You will find that harmless additives have been included to overcome the moisture-grabbing nature of calcium and magnesium chlorides.

Still another impurity is found in common salt and the amount may vary greatly. This is iodine, found as iodide ions (I-) in solution or sodium iodide or potassium iodide in solid crystal form.

Some salt water, especially that separated from crude petroleum and which was in the rock into which the oil well was drilled, may be many thousands of years old. The iodide ions may be as great as 80 parts per million (ppm), enough to make the recovery of free iodine attractive as a commercial venture if the cost of recovering makes the price of the product within range so a profit can be made after taxes are paid.

The interest in iodine, as most everyone knows, is because the human body needs a little of it in the thyroid gland. Lack of iodine produces an abnormal condition called goiter.

In Chicago, investigation of 2,000 dead dogs showed that 98 percent of them had goiter. After iodized salt came to be widely used, this disease became unknown among the Chicago dogs. Hopefully, a similar comment could be made about the families that these dogs served.

This experiment is to check on the amount of iodine as iodide ions present in common salt (U.S.P. grade) and in iodized salt.

MATERIALS NEEDED

Test tubes (20 ml) and stoppers and rack. Iodized salt; common salt; rock salt; sodium chloride, chemically pure (ACS specifications). Sodium iodide (NaI) or potassium iodide (KI). Distilled or deionized water. Containers for solutions. Liquid Freon®, tetrachloroethylene ($CCl_2:CCl_2$), trichloroethylene ($CHCl:CCl_2$), or carbon tetrachloride (CCl_4). These organic solvents must be used with strong ventilation. Pipets, balances. Freshly made saturated solution of chlorine (Cl_2) in distilled water.

MAKING STANDARDS

1. Weigh out 1.00 g of sodium iodide and dissolve it in 99 ml of

distilled water, a measured volume. Call this 1% NaI. Keep it in a labeled closed container. (If the iodized salt to be used later contains potassium iodide (KI), use KI where these directions read NaI.)

2. Use 10 ml, measured, of the 1% solution and mix it with 90 ml of distilled water. Call this 0.1% NaI solution.

3. Use 10 ml, measured of the 0.1% NaI and mix with 90 ml of distilled water. Call this 0.01% NaI.

4. Make also 0.001% and 0.0001% NaI solution similarly. Store each in a labeled bottle.

5. Take by means of a pipet, 5 ml of 1% NaI solution and add a measured 5 ml volume of chlorine water and 5 ml of the organic solvent. Stopper the mixture with a plastic cap or a plastic sheet over a cork and shake it well. Note the color produced in the organic solvent and save this tube, labeled 1%.

6. In a similar manner, measuring each time, use 5 ml of 0.1% NaI (or KI) and treat it in the same manner as in part 5. Use 5 ml of each solution you made, one at a time, and shake each with 5 ml of chlorine water and 5 ml of the organic solvent. Label each tube as to concentration. You now have a set of standards that show the colors in the organic solvent resulting from several concentrations of I-.

USING THE STANDARDS

1. Weigh out 50.0 g of iodized salt. Dissolve this in 450 g of distilled water. Use 5 ml of this solution of unknown iodide concentration and in like manner add 5 ml of chlorine water and 5 ml of the organic solvent; stopper and shake. Compare the color produced in the organic solvent with the colors in the standards already made. Estimate the percent of NaI (or KI) in the iodized salt.

Notes:

1. If you find that the store sample of iodized salt shows an iodide content between two of the percentage concentrations suggested as standards, it is left to the student to devise other standard solutions that show the degree of color between the two concentrations in steps of 0.1. Thus the percentage of I- in the sample may be estimated to the nearest 0.01 (or 0.001, etc.) percent.

2. Collect kelp or other types of seaweed. Dry the plant material, using a drying oven or an IR lamp if strong sunlight is not available. Weigh out 10.0 g of the dried powdered seaweed after it has been crushed in a mortar with a pestle. Add a measured volume of water to the sample, shake it well to leach out the I- in the dried weed. Test a measured volume of this solution as in part 5, and arrive at an estimated ppm value for I- in seaweed.

TESTS FOR NUTRIENTS

FATS

This experiment uses fats, many familiar methods of identification, and suggests a few additional aspects.

IDENTIFICATION OF FATS

A simple way to identify the presence of fats is to use a solvent for fat on the sample and dissolve the fat. Put a drop or two of the solution onto unglazed paper. Allow the solvent to evaporate. If the solvent is nonflammable, the paper may be warmed on a wire screen, held by tongs, and waved cautiously, wire down, over a small bunsen flame.

Hold the spot against a lighted background and it appears translucent; against a dark background it seems to be dark.

Test french fries or other food fried in deep fat. Compare the residual fat on McDonald's french fries with that on Howard Johnson's. Any two sorts may be used, of course.

1.) Weigh the samples A.)________grams B.)________grams

Use a liquid Freon® as the solvent, (or CCl_4 or $CHCl_3$), if used with care and adequate ventilation.

A thorough extraction may be accomplished by a Soxhlet extractor. Lacking this extractor, wash and rinse the material several times with the solvent.

Remove the potatoes from which the fat has been extracted, allow the solvent to evaporate, and weigh the greaseless spuds.

A.)________grams B.)________grams

2.) Find the mass of grease lost.

A.)________grams B.)________grams

How can you tell whether or not all the grease has been removed?

Where is the grease now? How can you find its mass? Which determination of mass of the grease is more accurate?

Compare the amount of grease lost with the amount of grease removed.

Repeat the previous experiment, but use two brands of your favorite sorts of potato chips, or two brands of canned fried shoestring potatoes. Other sorts of foods such as doughnuts, fried onion rings, Fritos®, and other foods (usually sold in a plastic bag) may be tested and compared (a.) between different brands or kinds, of the same product (baking-powder doughnuts vs. yeast raised doughnuts) and (b.) one product against another (fish vs. chips).

MATERIALS AND APPARATUS

Samples of fat-containing food. Solvent for fat: liquid Freon® ; CCl_4 extreme care; $CHCl_3$. Balance. Soxhlet extractor (not essential), unglazed paper. Grease-proof plastic sheet or aluminum foil for holding samples.

TESTS FOR NUTRIENTS

CARBOHYDRATES AND SUGARS

*FEHLING'S SOLUTION:

A. Dissolve 34.66 g $CuSO_4 \cdot 5H_2O$ in water and dilute to 500 ml.

B. Dissolve 173 g of sodium potassium tartrate (Rochelle salts $NaKC_4H_4O_6 \cdot 4H_2O$ and 50 g of NaOH in water and dilute when cold to 500 ml.

For use: Mix equal volumes of the two solutions at time of using. Boil sample with 5 ml of mixture of A and B.

*BENEDICT'S SOLUTION:

With heating, dissolve 173 g of sodium citrate and 100 g of Na_2CO_3 in 800 ml of water Filter if necessary and dilute to 850 ml. Dissolve 17.3 g of $CuSO_4 \cdot 5H_2O$ in 100 ml of water. Pour the latter solution into the former with continual stirring, and add enough water to make one liter.

*adapted from Handbook of Chemistry & Physics--Chemical Rubber Company

PRICES FROM A RECENT CATALOG

Fehling's Solution A	1 qt., \$2.73
Fehling's Solution B	1 qt., \$4.25
Benedict's Solution, qual.	1 qt., \$2.84
$CuSO_4 \cdot 5H_2O$	1 lb., \$3.64
Na_2CO_3	1 lb., \$1.95
$NaKC_4H_4O_6 \cdot 4H_2O$	1 lb., \$3.89
NaOH	1 lb., \$1.73
$Na_3C_6H_5O_7 \cdot 2H_2O$	1 lb., \$3.47

1 lb=454 g   1 liter=1.06 qt (liquid)

PROBLEM:

Assume no cost for ordering, delivery, transportation, billing, and unpacking for any item.

Is it less or more expensive to buy these solutions ready made or to make them from the components? Show calculations.

Compare the two solutions (Fehling's and Benedict's) by heating these samples to boiling with 5 ml of each solution, one at a time with a selection from this list.

1. corn syrup (Karo®)
2. sugar (sucrose) solution
3. sucrose solution which has been boiled with one drop of hydrochloric acid mixed with it.
4. honey
5. maple syrup ("pure")
6. molasses solution
7. a carbonated beverage (soft drink, Coke®, etc.)
8. the sugar-free variety of the same beverage, (Tab®, etc.)
9. solution containing a cyclamate
10. a solution of saccharin ®
11. solution of "Sweet and Low" or other sugar substitue packaged for table use.
12. light-brown sugar solution
13. dark-brown sugar solution
14. brown-sugar granules
15. starch suspension
16. starch suspension boiled with HCl
17. starch suspension mixed with saliva
18. a water extract of grass or hay
19. grass or hay which has been soaking in an enzyme that is used by animals to digest grass.

Keep careful records. Use comparable amounts of solutions of the same concentration, and compare the amounts of Cu_2O precipitate.

TESTS FOR NUTRIENTS

STARCHES

Almost everyone knows that iodine solution turns starch purple or blue. Iodine dissolves well in water if an equal mass of KI is included.

Use a medicine dropper and put a tiny drop of iodine solution on each of these materials: dry cornstarch, arrowroot starch, wheat starch, potato starch.

A pinch of each of the above starches boiled in a half test-tube full of water. (Notice effect of breaking cell walls around starch granules.)

Test various foods such as bread, cake, pretzels, a slice of banana and other cut fruit, whipped topping, cheese, yogurt, pizza crust, powdered milk. Also glue from the flap of an envelope, library paste, sizing, crinoline, cotton, nylon, other synthetic fibers, and saliva.

Make a tabular record of the results.

TESTS FOR NUTRIENTS

PROTEINS

XANTHROPROTEIC TEST

A simple test for the presence of protein is the xanthroproteic test. A drop of conc HNO_3 is placed on the sample. If protein is present, a yellow color is noticed. Rinse off the acid and add a drop of conc ammonia water. The ammonia must neutralize any HNO_3 remaining on the spot. The yellow spot turns orange.

If liquid protein is used such as egg white, coagulate it by heating before using it in the test.

Test a piece of fingernail trimming.

Test a fresh vegetable, a piece of white chicken meat, a piece of preserved meat such as baloney, fish, soy beans, dry beans, dry peas, rice, milk, cheese, cabbage, oxamide, yogurt, and biuret.

Keep a record of each result.

BIURET TEST

Use dilute $CuSO_4$ solution, 0.1 $\underline{M}$ $CuSO_4$ solution mixed with one-half its volume of water. Put a drop of this dilute solution on the sample. To the spot on the sample add 1 ml of 6 $\underline{M}$ NaOH solution (240 g/liter). A reddish violet to violet-blue color results. This effect is evidence of a peptide linkage or one similar to it.

Try all the materials listed above, and compare the two tests in their effectiveness. Use the evidence shown in the tabulation that you made.

PERCENTAGE OF FAT IN A FOOD SAMPLE

"Milk is 96 percent fat free," reads a billboard. True. Milk is required by law generally in most states to contain four percent butter fat.

Find out how much fat your milk sample contains.

Shake a weighed sample of milk in a separatory funnel with chloroform; a solvent for fat. Draw off the chloroform layer and save it in a weighed evaporating dish or a distilling flask. Evaporate the chloroform layer by mild heating in a hood. Try a steam bath as a source of heat first. The more ecologically minded will want to distill off and collect about 3/4 of the chloroform from the solution before transferring it quantitatively to an evaporating dish. Weigh everything and calculate the percentage of butter fat recovered.

CAUTION: Avoid inhaling chloroform fumes.

Devise ways to find the percentages of fat in other foods.

RECOVERY OF IODINE FROM SEAWEED

INTRODUCTION

Oysters have always been prized as a food. Their nutritional value is limited in terms of carbohydrates and fats, but they are alleged to be a source of "minerals," especially iodine in the form of iodides.

An interesting problem is suggested. Seaweeds grow fastened to rocks chiefly, and seawater passes over and around this vegetation. The thin gruel that is the sea supplies food to all the millions of creatures living within its great domain. Take kelp, ribbon weed, for example. This long brown ribbon may grow more than thirty feet in length, supported by and waving in the seawater containing hydrated iodide ions (I^- (aq)). Kelp takes all the I^- it needs from the sea, but when it gets enough, it stops and the I^- drift by it, uncaptured. What is the mechanism of this selective absorption? How does the plant know when to start and when to stop consuming I^- in its diet?

WHAT TO USE

Dried kelp or other seaweed; balance; motar and pestle; 6-M hydrochloric acid; chlorine water; evaporating dish, large; bunsen burner; soluble starch solution; 500-ml Buchner funnel; separatory funnel; carbon tetrachloride (use with ventilation) or liquid Freon® (less toxic).

WHAT TO DO

1. Dry the kelp thoroughly, using an oven or IR lamp if sun drying does not make it completely dry.

2. Crush the kelp in a mortar with a pestle to a powder.

3. Weigh the beaker in which the kelp is to be treated and weigh it again about 1/3 filled with kelp powder.

4. Add enough water with stirring until a mush is formed. Then add a few drops of 6-M hydrochloric acid and mix the acid thoroughly.

5. Add 5 ml of fresh chlorine water and distilled water until the mixture stirs readily.

6. Filter the material, using a Buchner funnel. Press the paste gently with the flattened end of a stirring rod and obtain the maximum amount of filtrate.

7. Put the portions of filtrate in a separatory funnel. Add about 5 ml of carbon tetrachloride to dissolve the iodine. (Use extreme care and excellent ventilation when using carbon tetrachloride. Its fumes are toxic.)

Close the top of the separatory funnel and shake the mixture.

8. Separate the carbon tetrachloride layer and save it in an open beaker.

Discard the water layer. Repeat this operation until all the iodine has been extracted from the water by the carbon tetrachloride.

9. Collect the CCl_4 extracts in a weighed small beaker. Evaporate the solvent in a hood by putting it in a larger beaker of hot water.

10. When the solvent has all evaporated, weigh the beaker and the iodine. Calculate the percentage of iodine in the original sample of kelp.

11. What does each step accomplish? Are all these steps needed?

TESTING BREAD FOR CALCIUM PROPIONATE

DISCUSSION

Keeping loaves of bread in a refrigerator retards the growth of a green mold on the bread. The obvious disadvantage is that bread is bulky and probably the refrigerator has already a near-capacity load. Another way to accomplish the same result is to make bread unpalatable to mold. This hostile environment to mold can be made by adding a small amount of harmless calcium propionate to the dough. Look on the bread wrapper and see whether or not this salt-like compound is present. It extends the shelf life of bread, especially after the bread reaches a home. If mold appears, many housekeepers throw the bread out to feed the birds, racoons, opposums, or other wildlife.

SUPPLIES

Slice of bread to be tested, 6-M sulfuric acid (H_2SO_4), 95% ethanol (C_2H_5OH), 250-ml beaker, 20-ml test tube, bunsen burner, test tube holder.

THEORY

The presence of calcium propionate might be detected by the presence of calcium (Ca^{2+}). Calcium compounds, however, are possible in other components of the dough. The propionate group is less likely elsewhere and is therefore selected for detection, although its detection is difficult because of the small amount present.

Adding sulfuric acid precipitates Ca^{2+} as $CaSO_4$ which is slightly soluble, and forms some propionic acid (C_2H_5COOH), also called propanoic acid, in water solution. Ethyl alcohol in the presence of sulfuric acid (already present) as a catalyst, permits the formation of some ethyl propionate ($C_2H_5COOC_2H_5$) which has a pineapple-like odor.

$$(C_2H_5COO)_2Ca + H_2SO_4 \longrightarrow CaSO_4(s) + 2C_2H_5COOH$$

$$C_2H_5COOH + C_2H_5OH \rightleftharpoons H_2O + C_2H_5COOC_2H_5$$

The equilibrium involved in esterification may not go very far to the right.

WHAT TO DO

1. Place a slice of bread in a 250-ml beaker and add 100 ml of water. Use distilled or deionized water if the local tap water is "hard" water. Allow the water to dissolve the calcium propionate as well as other soluble materials. Stir the mixture with a glass rod or a spatula.

2. Drain off about 10 ml of the solution into a test tube holding back as much of the sopped-up bread as possible by a spatula or glass rod.

3. Add 6-M (dilute) sulfuric acid to the contents of the tube. Watch for an immediate precipitate obscured by the cloudy liquid. Five ml of acid should be enough.

4. Mix 3 or 4 ml of 95% ethanol with the contents of the tube, and heat the tube evenly. As the contents of the tube approach the boiling point, waft some of the vapors toward your nose. Some excess alcohol (b.p. 78.5° C) may evaporate first. The ethyl propionate (b.p. 99° C) vaporizes just before water boils.

In a trial a small amount of a definite odor of pineapple was detected. If you don't have success after two tries, turn to next section.

OPEN ENDEDNESS

1. Would it help any to filter the liquid after the $CaSO_4$ has precipitated?

2. Could oxalic acid ($(COOH)_2$) be used instead of sulfuric acid? What about oxalic acid and a small amount of sulfuric acid both?

3. Could a small sample of the ester be isolated? Add a boiling chip, and prepare to distill the mixture, saving the fraction that evaporates and is condensed from 95°C until just before the water boils. This is necessarily a small quantity.

GENERAL CAUTION: Never let the contents of a distillation flask "boil dry." The flask may break, or the contents in some distillations may explode.

While the boiling point of pure ethyl propionate is 99°C, and that of propionic acid is 141°C, the acid is soluble in water in all proportions while the ester dissolves only slightly, 0.24 g per 10 ml of water.

For a more technical attack on the identification of propanoic acid see Manual of Methods, Eleventh Edition, Association Analytical Chemists, Method No. 14.086.

CAFFEINE FROM TEA

INTRODUCTION

The compound caffeine was first isolated from coffee beans by Runge in 1820, and from tea by Oudry in 1827. Carl Jobst of Stuttgart reported in Justus Liebig's (the condenser man) Analen die Pharmacie his results of isolating and analyzing thein (as it was then called) from tea.

The report was published in 1838 in Heidelberg. Jobst's analysis shows:

	Jobst	Calculated
C	49,798	49.48
N	28,532	28.85
H	5,082	5.19
O	16,288	16.48

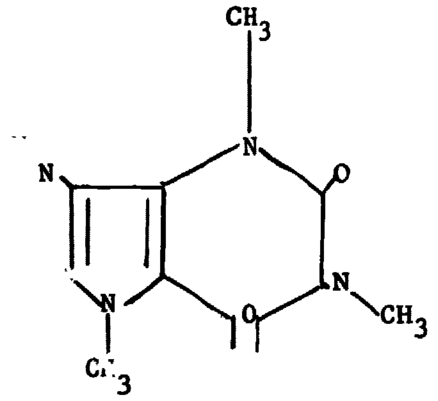
The theoretical composition of caffeine, deduced from its formula is shown alongside the analysis of 135 years ago. Considering the fact that Jobst worked with impure reagent chemicals which he first purified, and that he had no borosilicate glassware (such as Pyrex brand), and that he had no elaborate machines such as U-V spectrometers to check his analysis, and that he probably had only a vague idea of the structure of caffeine, Jobst did a job which every chemistry student can admire. In fact, such a high degree of precision seems impossible.

Take carbon, for example: 49.798 Jobst
-49.48 Theoretical
00.32 Error →

Calculation of percentage error:

$\frac{\text{error}}{\text{correct value}}(100) = \frac{0.32}{49.48}(100) = \text{ca } \frac{0.65}{100.00}(100)$, which is 0.65%, less than one percent in error.

STRUCTURE



Caffeine
(an alkaloid)

TOXICITY

Caffeine is found in kola nuts as well as in coffee and tea. It is also made synthetically.

It is a moderate poison in doses of 1 grain (about 0.15 gram; 28 grams= 1 ounce) or more.

Research experiments show that 200 mg/ml inhibits the activity of the enzyme DNA polymerase. Caffeine in carbonated beverage does not exceed 0.02 percent.

PROPERTIES

Caffeine forms beautiful silky crystals. The compound dissolves well in chloroform but it dissolves only a little in water, alcohol, or ether. When heated, caffeine loses water at 80° C and it melts at 236.8° C.

A randomly selected tea bag (Lipton's®) held 2.5 g of tea.

Now let's go after the compound that is responsible for most of the stimulating effects of coffee, tea, Coke®, Pepsi® and other beverages.

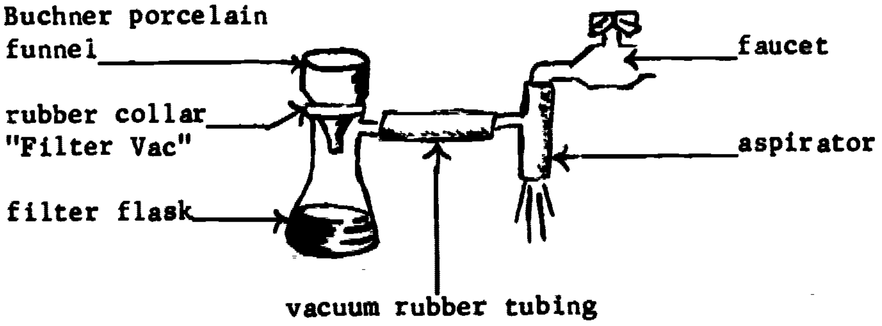
WHAT TO DO

1. Fill a one-pint vessel (500 ml beaker) 4/5 full of water. Add the contents of four tea bags, without the paper. Boil this strong tea for 20 min.

2. Make a solution of lead acetate $[(CH_3COO)_2Pb]$ 4 g in 40 ml of water. Take great care to keep the lead acetate off your hands. Do not inhale dust from it. Wash your hands after making the solution. Add a few drops of acetic acid and stir until the lead acetate solution becomes clear. (The equilibrium involving the hydrolysis of lead ions is shifted to the left--for those who wonder how the magic is done.) Add the lead

acetate solution to the tea, stir it well, and filter the mixture which is hot, preferably by the use of a Buchner funnel which has air drawn through it by an aspirator.

(Look up Bernoulli's principle and find out how an aspirator works.)

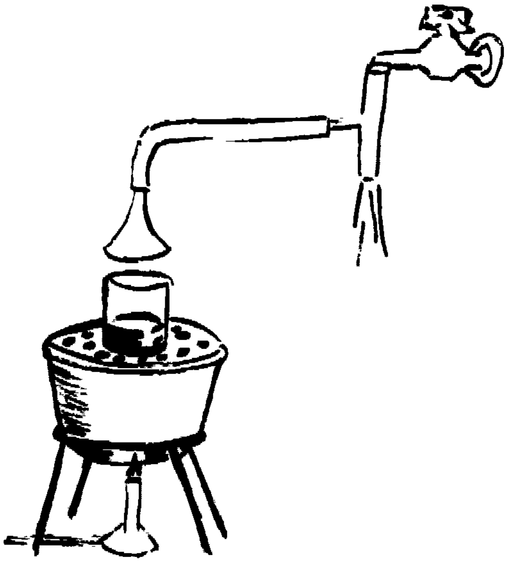


3. Discard the stuff precipitated by the lead acetate and caught on the filter paper of the funnel. Now continue to boil the clear filtrate that came through the filter paper to a volume of 30 ml (a 6 inch x 5/8 inch test tube holds about 15 ml or 20 ml). Add 25 ml of chloroform after the liquid comes to room temperature. The chloroform washes the caffeine out of water when the two are shaken together but be careful that the chlorofrom doesn't harm you. Work with a draft blowing away from you. Mix the liquids thoroughly and filter once more.

4. Separate the two layers of liquids by means of a separatory funnel. If you don't know which liquid is which, add a drop of water and see where it goes. Save the chloroform layer in a beaker or a flask.

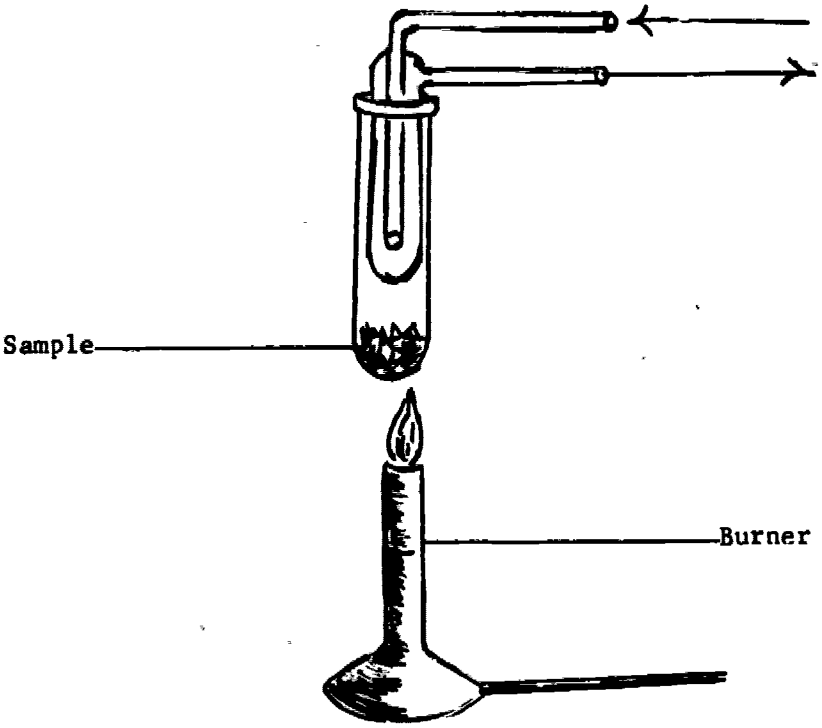
5. Twice more, add 25 ml of chloroform. Shake thoroughly, separate and save the chloroform layer.

6. The caffeine is in the chloroform. Now get rid of the chloroform and the caffeine remains. You can distill the chloroform off partly, or you can blow a draft of air over the chloroform, or both. Another way to remove the chloroform is to place the solution beneath the large end of a funnel which is attached to an aspirator. Heat the solution by hot water or steam while this happens.



7. Collect the crystals. Weigh them. Calculate the mass percentage of caffeine in the tea.

8. For those who wish to do an extra nice job, purify the crystals by subliming them. Heat them in the bottom of a test tube. The top of the test tube carries a tightly fitting stopper through which a cold-finger (mini) condenser projects.



9. Weigh your refined product. The next step is to analyze it just as Jobst did.

NEEDED MATERIALS AND APPARATUS

Four tea bags (or loose tea); pint-size beaker (500 ml); lead acetate (4 g); 100 ml bottle or beaker in which to make lead acetate solution; acetic acid; 75 ml of chloroform; aspirator; Buchner funnel; filter flask (250 ml); connecting rubber vacuum tubing; funnel; 250 ml beaker; steam or water bath; bunsen burner; separatory funnel, 250 ml.

If sublimation is included: 6 x 1 inch test tube, cold-finger condenser, small flame on burner; connecting rubber tubing.

REFERENCE

For isolating both caffiene and benzoic acid from cola beverages, see Laswick and Laswick, JOURNAL OF CHEMICAL EDUCATION, 49, 10, p. 708 (1972).

IRON IN FOODS

INTRODUCTION

That exopthalmic navigator, Popeye, The Sailor Man, extols the value of canned spinach by song, example, and precept. Iron, a strong metal, is connected with strength in the body which seems reasonable enough in some ways.

Such a connection may be more imagined than real, but a highly refined diet may be lacking in enough iron. Iron is certainly needed to make hemoglobin in red blood corpuscles.

This experiment seeks to find out how much iron is in a sample of food and to supply a partial answer to the question, "How much?"

MATERIALS

Test tubes (15 ml); test-tube rack; bunsen burner; crucible or evaporating dish; samples of food such as raisins, dried currants, leafy vegetable (spinach, chard, escarole, beet greens, etc.); 0.1-M KSCN solution; balance; 250 ml beaker.

PROCEDURE

General: A weighed sample of dried fruit or vegetable is heated and burned until only an ash of mineral matter remains. The ash is tested for the presence of Fe(III) by adding a solution of KSCN, which forms a deep-red colored solution (not a precipitate). The net ionic equation is:

$$Fe^{3+} + SCN^- \rightleftharpoons FeSCN^{2+} \quad \text{(deep red)}$$

CHECK BY BLANK

Use a crucible or porcelain evaporating dish but no sample. Perform the operations that follow in order to be sure that iron isn't getting into your experiment from the environment. The ceiling, iron wire screen, dust of the air, and other sources of iron compounds are possible. Without running a blank, one cannot be sure that the experiment is valid.

PREPARING THE STANDARDS

1. Weigh out 1.9 g of anhydrous $FeCl_3$ (Fe_2Cl_6). The hydrated $FeCl_3$ may also be used or $Fe_2(SO_4)_3$.

2. Measure 99 ml (99 g) of distilled water into a 250-ml beaker.

3. Mix the iron compound with the water and stir it until no solid remains undissolved. Label this solution 1% $FeCl_3$.

4. Pipet out 10 ml of the $FeCl_3$ solution, add a measured 90 ml of water, and mix thoroughly. Label this solution 0.1% $FeCl_3$.

5. By similar dilution procedures, prepare 0.01%, 0.001%, 0.0001%, and 0.00001% $FeCl_3$. Label each solution appropriately.

6. Remove by a pipet 5 ml from each of these $FeCl_3$ solutions. Add to each 5 ml of 0.1-M KSCN solution.

7. If the color in the last test tube is faint pink or colorless, go on to the next part. If not, extend the range of your standard by appropriate dilution.

TESTING FOR IRON

1. Weigh a sample of dried raisin (for example). Raisins as they come from the grocer's box should be dried to constant mass.

2. Put the weighed sample into a porcelain dish or crucible. Heat it strongly until the sample burns and an ash remains. The ash contains iron compounds from the sample.

3. After the dish has cooled, add 5 ml of distilled water (iron free), stir and transfer the mixture to a test tube. Add 5 ml of 0.1-M KSCN solution.

4. Compare the color obtained with the colors in the standards of known concentration, and estimate the percent of iron in the original sample.

5. Run a duplicate test, possibly at the same time as part 4, to confirm your results.

NOTES:

1. If your results do not fit the scale shown by the standards, you may have to extend the scale of the standards. If the scale of the

standards is too coarse, you may need to change a certain range of the dilutions that were 10 ml + 90 ml of water to become 2 ml + 8 ml water, 3 ml + 7 ml water, and so forth.

2. In finding the percent of iron in the sample, remember that the standards are based on pure iron compound which itself contains a certain percent of iron as Fe^{3+}.

The final calculation should go back to the mass of the sample which is not a pure iron compound.

WHAT MAKES POPCORN POP?

A corn popper is a 250-ml erlenmeyer flask warmed on a hot plate and loosely stoppered. Practice until you can pop corn one kernel at a time without scorching it.

Use about a dozen kernels, handled by forceps, weighing each before and after popping. Treat the data as an application of statistics, finding the mean value and the sample standard deviation.

It's a mighty interesting (and rewarding, with NaCl) experiment.

See A "Relevent" First Experiment--Macomber, Roger S., JOURNAL OF CHEMICAL EDUCATION, 49, 10. p. 714, (Oct., 1972).

TOASTING

Everyone knows that toasting improves the taste of bread, especially the taste of bread that is slightly stale. The reason for the new taste is that a new substance, dextrin, has been formed in the bread. The heating causes a chemical change by decomposing partially a part of the bread. Decomposition by heating may be called pyrolysis.

-Starch-

WHAT TO DO

1. Take a borosilicate glass test tube, preferably one that is in less than first-class condition, perhaps a chip missing from the lip. Hold the tube in a test-tube holder. Put cornstarch or wheat starch in the test tube to a depth of about 1.5 cm. Swirl the contents of the tube as you heat the contents so that the heat will be evenly distributed. The starch darkens, but avoid so much heat that the starch forms black carbon.

An even, yellow-brown color throughout should result. Pour out the toasted starch onto a piece of paper. When it is cool, taste it cautiously.

Put about one-third of the toasted material in an evaporating dish. Add enough water slowly and stir with a spatula until a thick gruel-like paste is formed. Spread the paste onto one-half of a piece of paper. Let the paste dry, hastened by a lighted electric lamp. Moisten the paste and glue the piece of paper to your laboratory report.

Dextrin is used on adhesive postage stamps and on the flaps of envelopes.

-Sugar-

MATERIALS AND APPARATUS

Cornstarch, 2-cm square of paper, Pyrex® or Kimax® test tube, test-tube holder, bunsen burner, wire screen, electric light bulb, evaporating dish, spatula (2) Na_2CO_3, (3) $KHSO_4$.

WHAT TO DO

2. Repeat this experiment but use sugar (sucrose) instead of starch. Mix a small quantity of sodium carbonate with the sugar, and heat it gently. Do not heat enough to melt the sugar or to carbonize it. When the contents of the test tube have cooled, pour out the contents into a dish. Taste very cautiously and see whether or not you detect the flavor of caramel.

-Fat-

3. Obtain a sample of acrolein so that its odor may be used for identifying the compound.

This experiment is similar to part 1, except the olive oil, coconut, peanut oil with a sprinkling of $KHSO_4$ is used. After heating cautiously, even more cautiously smell your sample and compare its odor with that of acrolein. Be sure to waft the fumes gently and in small quantity to your nose. Acrolein irritates the eyes.

Alternately, use glycerol instead of liquid fat.

4. Summarize the results of toasting.