For Teachers

Popcorn – a fat free snack

Developers: Rely Shore

Institute: Weizmann Institute of Science
Country: Israel

Subject: Chemistry, Science for all

Grade level: 9-12 grades

Curriculum content: State of matter

Kind of activity: Inquiry experiment

Anticipated time: 4 -5 hours (2 hours for the first phase, 2 - 3 hours for the second phase)

Objectives/Competences

Inquiry laboratory experiments

In the beginning of the twenty-first century, we are entering a new era of reform in science education. Both content and pedagogy of science teaching are scrutinized. In addition new standards, that are intended to shape and renew science education, are emerging. The National Science Education Standards (National Research Council 1996) specially addresses inquiry-based methods in teaching Standards and professional development for K-12 science teachers.

In high schools in Israel an inquiry-type laboratory was implemented into the chemistry curriculum (Hofstein, Shore and Kipnis, 2004). These laboratories procedure included several phases. In the first phase (the pre-inquiry phase), the students were asked to conduct an experiment in accordance with a literature procedure. During the pre-inquiry phase, the teacher did not give the students any information or explanations about the phenomena. This situation gave the students an opportunity to ask questions about the phenomena they observed and about the experiment itself. The second phase of the experiment is the inquiry phase. In this phase the students are asked to write a list of all the questions that were originated from the first phase (Hofstein, Navon, Kipnis and Mamlok-Naaman, 2005). Then they chose one question for further investigation: they rephrased the question as an inquiry question, hypothesized, planed an experiment, and conducted the experiment. Finally the students analyzed their findings and reach conclusions. The use of inquiry – type experiment allowed the students to learn and experience science on their own and provided them the opportunity to construct their knowledge.

Stages of inquiry: carrying an experiment out according to instructions; collecting and recording observations; questioning, choosing and formulating an inquiry question and a reasonable hypothesis, planning an experiment, and reflection regarding the whole process.

Working in groups

In the inquiry laboratories students work in small each group contains 2-3 students. Working in a small group enables the students to be experienced in socio cultural setting. The learning process emphasizes the importance of interpersonal skills. Almost all the parts in the inquiry experiments involve these skills, for example: team work in the practical work, group discussions, and group reflection. Part of the assessment is focus on the students' contribution to the group work, as will be elaborate in the assessment part.

In teaching chemistry

- Clarifying terms such as: pressure, boiling and vapour pressure.
- Scientific aspects of processes occurring while preparing popcorn.
- Tying chemistry to every-day life.

In teaching as inquiry

The main aim of this activity as presented here, is to become familiar with and get experience in different stages of inquiry : carrying it out according to instructions; collecting and recording observations; questioning, choosing and formulating an inquiry question and a reasonable hypothesis , planning an experiment, presenting results, drawing conclusions and discussion
This experiment can be used for other purposes and/or specifics in inquiry instruction - from learning and reinforcing certain basic research skills (such as focusing on the distinction between observation and explanation) to development of all research skills including through experience in a mini research.
Another important aim that could be achieved with this activity is increasing motivation among the students, especially when it constitutes an opening experiment in learning “by the inquiry approach”

Task description

This activity combines a well known cooking activity (preparing popcorn) with an inquiry process. It does not require any preliminary scientific knowledge; therefore it can be modified to any level of science teaching. Usually the popcorn we eat is made with butter or oil. In this activity we will check whether the use of fats is really needed in order to prepar popcorn.

Teaching guide

Equipment and Materials:

Electric hot plate or Bunsen burner
Cooking pot with a glass cover
1 spoon of oil
A handful of popcorn

Requirement of Prior Knowledge

No special prior knowledge is required.

Connection to the Syllabus

The activity is not necessarily connected to a specific study subject or topic and therefore it can be carried out at every age level and in every stage of learning. In accord with the learning stage and level of the students, ties and contexts can be developed with the subjects: energy; structure and bonding, carbohydrates, kinetics and thermodynamics.

Position/Place in the Teaching/Instruction Succession/Series

Since the experiment is not contingent on prior knowledge and is not connected to a specific study subject or topic, it can be integrated at any stage in chemistry studies. The experiment is brought here as an opening learning experiment in the program “Chemistry by an inquiry approach” for the following reasons: The subject ties in with ordinary everyday life because popcorn is a popular product and therefore dealing with it is likely to increase the motivation. There is a variety of inquiry questions that can be examined by relatively simple laboratory means.

Time Managing

The following suggested division of time is suitable when the experiment is conducted as an opening experiment. One lesson to prepare the popcorn (if the possibility of doing it in school is chosen) + recording observations + discussion on the differences between an observation and an explanation.
One lesson to concentrate on questioning, the discussion on questions and choosing an inquiry question.
One lesson for planning the experiment, presenting the various planned experiments before the class and a discussion on them. One lesson for carrying out the planned experiment and writing the report.
One lesson for presenting the results of the different experiments and for a class summary.

Specific safety remarks

The students work with a Bunsen and/or gas burner and/or an electric plate. Therefore, close attention should be paid that they work standing and with their hair pulled back. The utensils and the electric-plate are very hot and the oil reaches very high temperatures, therefore contact with the hands should be

avoided and special gloves of heath isolating material should be used. .If the students plan to replace the oil with other liquids, close attention should be paid that combustible liquids be heated only on an electric plate and that volatile liquids be heated under a fume hood.

Remarks and instructions from teachers' experience

Many students ask to use a mass of corn kernels as an independent variable - since the corn kernels adsorb the oil during preparation of the popcorn, the mass of kernels cannot be measured before and after the experiment, and therefore it should be measured as a beginning mass together with the oil. In many cases students choose to use the number of corn kernels popping as a variable. Since only rarely do all of the kernels pop, it is expedient taking part of the popped kernels as a measure for comparison – for example, half of them (or another percent), but not wait to all of them pop. Since the "behavior" of the popcorn raises many questions on various inquiry levels, it is possible also to first make assumptions connected to some of the arising questions and only afterwards formulating the suitable inquiry question.

Recommendations in respect with the variety of additional working possibilities:

Many teachers contributed to this part, from their own experience: Mira Kipnis, Devora Katzevich, Dalia Ovadiahu, Daniella Libman, Otilia Rosenberg, Nurit Ariel, Ronit Barad, and others…

Home assignment - an inquiry experiment according to Daniella Liebman's suggestion: Why does popcorn pop?

Prepare popcorn in a pot or in the microwave oven at home (salt and butter can be added for flavour)
Record all the observations related to the phenomenon, from the kernel stage to the stage in which the popcorn is eaten. You are kindly invited to bring the end product to the class.
List all the observations you collected in an orderly manner.
Express an opinion on the question: Does who bought the popcorn kernels and where they were bought have any importance?
Does it have any importance which company markets the kernels that you make?
Write a hypothesis that explains why popcorn puffs up.
On what previous knowledge is the assumption based?
Does the hypothesis conform to your prior knowledge?
What additional information would you have needed to have had in order to base the assumption?
Suggest an experiment for confirming the assumption.

After carrying out the experiment at home or at the end of the activity, a summary discussion can be held in the class in which some or all of the research skills required in the various stages could be related to: Observations - The observations that were collected before heating the kernels, during the heating and after the heating. Likewise, the following can be related to: the amount of kernels (that were taken, that popped, that became black or did not crack), their form, colour, size and hardness, the noise of the

popping, the intensity and rate of the popping in the course of heating the kernels and sometimes after it, the heating time required, the drops accumulating in the experiment and the smell
Questioning - It is worth to allow the raising of as many and as variegated questions as possible connected to the observations collected. At the end of the discussion on the questions, it is recommended devoting attention to and dealing with the choice and formulation of an inquiry question.

Examples of inquiry questions chosen by the students in the different classes in the course of the "popcorn" activity:

Is the mass of the popcorn kernels before and after popping equal?
How will replacing the oil by other liquids affect the percent of "exploding" kernels?
Do different popcorn kernels (from different companies) have different effects on the amount of kernels that pop?
Is the amount of kernels popping a function of popcorn kernels from different companies?
What is the connection between the temperature of the surroundings and the height the popcorn jumps to?
What is the connection between the drying time of the popcorn kernels and the number of kernels that pop?
The hypothesis, the plan of the experiment, the conclusions, etc. … should be related to in the discussion.

Suggestions for further research directions:

The influence of different treatments (such as: drying, soaking, damaging the hull, etc.) of the kernels on the quality of the popcorn (such as volume), on the percent of kernels popping, on the time required, etc.
The influence of various changes in the work environment (such as: different sources of energy, the temperature, the equipment and the vessel used, the additives, etc.) on the quality of the popcorn.
The examination of different kinds of popcorn (from different companies, different kernel sizes, different colours and hues.) can constitute a basis for a mini consumer research.

Teacher notes

Specific security notes:

The students work with bunzen or hot plat at high temperatures, therefore they should stand when they heat the popcorn, their hair should be gathered, they should use special isolated gloves when they touch the hot equipment.
If the oil is changed by organic liquids, the heating should be done by electric plat and not by open fire.

Inquiry directions that were suggested by the students:

The influence of some operations that had been done with the seeds before the heating (namely: drying, immersing in water, cutting the shell etc.), on the popcorn: the size of the popcorn, the amount of exploding seeds, the time that is needed etc.

The influence of the work environment (namely: different energy suppliers, different temperatures, different vessels' volume and shape, different amounts of oil, additives etc.) on the popcorn.
Checking different kinds of popcorn (different suppliers, different seeds' sizes, different seeds' colors etc.).

Background and Information Concerning the Experiment

History - The source of the word "corn" goes back to the period of the pyramids in ancient Egypt, but took on different meaning in different places - In England, for example, the word "corn" meant wheat.
At the beginning of the 16th century popcorn constituted an integral part in the life of Indian tribes, who used it both as a food and as a traditional ornament for covering the head, for stringing necklaces, and also as a symbol of the status of the gods.
In 1890 popcorn became very popular and during World War II, when there was a shortage in sugar for producing sweets, popcorn consumption rose three-fold.
Milestones in preparing popcorn:
One of the oldest ways of preparing popcorn is heating sand in an oven, and when the sand is very hot, putting the corn kernels on it
In 1893 the first portable popcorn machine was invented by the American, Charles Carters.
Percy Spencer, a scientist in the radio-active radiation-based industries, tried to isolate radio-active rays for use in World War II/the Second World War - and made a breakthrough in the development of the microwave oven. Popcorn constituted a key factor in many of the experiments he conducted.
In the 1940s popcorn for preparing in a microwave oven was first produced.
Contrary to sweet corn, preparing popcorn kernels is done by drying them on the stalk to around 16% moisture - afterwards it is harvested and dried to around 13.5 humidity.
Varieties: There are more than 700 kinds of popcorn.
What happens? How? - The external hull of the kernel contains mainly starch and water. When the kernels are heated, the moisture within the kernel turns to into water vapor, creating pressure inside the kernel. At any temperature between 170^{o}C and 220^{o}C the pressure created within the kernel rises to a point that the exterior hull cannot retain its organic entiety any more unity/remain whole (the pressure reaches around 9 atmospheres) and in the end the vapor is freed through a "large explosion" (the pop).
“The explosion” turns the starch (which becomes white in the course of heating even before popping) from inside the kernel outward. This turnout is accompanied by a release of steam from within the kernel, which is the reason for the starch getting an airy flabellate form.
When the outside hull of the kernel is cracked and/or faulted, the vapor is released in the course of the heating, the high pressure necessary for popping isn't created, and the kernel doesn't pop.

Referrals to further reading -

More information about popcorn, including the history of popcorn, more exlanations about the process of the formation of popcorn and advises can be found in: http://www.popcorn.org.

Linking to real life

Air popped popcorn is low in calories and fat, contains no sodium, and is sugar free, which makes it an attractive snack for those who want to avoid these substances. The actual fat, sugar, and sodium content depends on the preparation method. The energy value per 100 grams is 380 kcal, while the weight of one cup of popcorn is 8 grams. 100 grams of popcorn consist of 4 grams of fat, 12 grams of protein and 2.7 milligrams of Iron. Moreover, the popcorn is naturally high in fibbers.