# Fruit Juice Inquiry: Teacher Notes

## Overview/Introduction: Teaching and learning context

St Ignatius College Geelong currently has a major inquiry and communication task in each of years 7-10, and there is desire to develop an inquiry and communication task involving the chemical sciences. While acid-base titrations are not part of the Victorian Curriculum F-10, there is a desire to introduce year 10 students to this technique, to better prepare then for VCE chemistry.

It is intended that the major inquiry and communication task would extend over several lessons, with students working in teams to produce a poster, communicating their inquiry and the results of that inquiry.

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|---|---|---|
| Lesson 1 | Investigation of the contents of citric juice | ***Individually*** |
| Lessons 2 – 3 | Investigating how to test the acidity in citric juice | ***Group*** |
| Lessons 4 – 5 | Carry out investigation | ***Group*** |
| Lessons 6 – 7 | Completing the Scientific Poster | ***Individually*** |

## Curriculum Outcomes: Victorian Curriculum F-10

Levels 9 and 10

### Science as a human endeavour

- [Partial] The values and needs of contemporary society can influence the focus of scientific research (VCSSU116)

**Science Understanding: Chemical sciences**

- [Partial] Chemical reactions, including combustion and the reactions of acids, are important in both non-living and living systems and involve energy transfer (VCSSU126)
  - investigating reactions of acids with metals, bases, and carbonates

## Teaching and learning concept for the laboratory learning activity

Kidney stones are a painful medical condition caused by the formation of solid particles (stones) from waste products that have been filtered from the blood by the kidneys. When these kidney stones move into the urinary passages, they can cause blockages resulting in severe pain. Kidney stones can also damage the urinary passages, resulting in blood in the urine. Urine may also appear cloudy or have bad smells if there is also an infection.

The lifetime risk of developing kidney stones is one in ten for Australian men and one in 35 for women [Footnote [4]].

The most common types of kidney stones are those formed from calcium combined with oxalate or phosphate. The best way of lowering the risk of all types of kidney stones is to drink lots of water. Research indicates that juices, fruits and vegetables that are high in citrate or citric acid may lower the risk of forming calcium oxalate kidney stones [Footnote [5]].

While fruit juices contain several types of food acids, citric fruit juices have citric acid as the major food acids. The amount of citric acid in the juice of various citric fruits (oranges, lemons, limes, grapefruit) is well approximated by the total acidity as determined by NaOH titration using phenolphthalein indicator [Footnote [6]].

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4 Kidney Health Australia (2016), “Kidney stones: Who is at risk?”, <kidney.org.au/your-kidneys/detect/kidney-stones/who-is-at-risk-438> (accessed 10 September 2016).

5 Heilberg, I. P. (2000). Update on dietary recommendations and medical treatment of renal stone disease. Nephrology Dialysis Transplantation, 15(1), 117-123; Meschi, T., Maggiore, U., Fiaccadori, E., Schianchi, T., Bosi, S., Adorni, G., . . . Borghi, L. (2004). The effect of fruits and vegetables on urinary stone risk factors. Kidney International, 66, 2402–2410.

6 W. B. Sinclair, E. T. Bartholomew and R. C. Ramsey, "Analysis of the organic acids of orange juice", Plant Physiol., 1945, 20, 3-18 <www.plantphysiol.org/content/20/1/3.citation>.

## *Inquiry Skills*

This is an inquiry activity that can be adjusted by the teacher to be as guided or as open-ended as desired. The student notes begin with specific directions but later questions allow students to conduct more independent investigations. The teacher may, however, decide to provide close guidance and direction throughout the activity.

Teachers may use the inquiry scaffolding tool[7] to assist decision making about the degree of support to provide students for each phase of the inquiry process.

7 Inquiry scaffolding tool. National Research Council (2000); Bruck, L.B., Bretz, S.L., & Towns, M. H.,2008. Adapted for the Victorian Curriculum by Lim, K. F. (2016), unpublished.)

| Curriculum outcome (slightly paraphrased) | Prescription | Confirmation | Structured Inquiry | Guided Inquiry | Open Inquiry | Curriculum outcome (slightly paraphrased) |
|---|---|---|---|---|---|---|
| Formulate questions or hypotheses (VCSIS134) | No question | Student engages in a question provided by teacher, or other source | Student sharpens or clarifies a question provided by teacher, or other source | Student selects among questions, poses new questions | Student poses a question | Formulate questions or hypotheses (VCSIS134) |
| Plan, select and use appropriate investigation (VCSIS135) | Student is given plan of investigation | Student uses a plan provided by teacher, or other source | Student sharpens or clarifies a plan provided by teacher, or other source | Student selects among plans, poses new plans | Student plans, selects and uses appropriate investigation | Plan, select and use appropriate investigation (VCSIS135) |
| Select and use appropriate equipment and collect and record data (VCSIS136) | Student is given data | Student is told how to use equipment and how to collect data | Student is told how to use equipment and asked to collect data | Student is directed to collect certain data and selects appropriate equipment | Student determines what is appropriate equipment and data and collects data | Select and use appropriate equipment and collect and record data (VCSIS136) |
| Construct and use representations, to record and summarise data (VCSIS137) | Student is given representations and summaries of data | Student told how to represent and summarise data | Student is guided to represent and summarise data | Student selects among representations and summaries | Student determines and uses appropriate representations and summaries | Construct and use representations, to record and summarise data (VCSIS137) |
| Analyse patterns and trends in data, and draw conclusions (VCSIS138) | Student is given conclusions | Student is given trends in data and told how to draw conclusions | Student is given trends in data and guided towards conclusions | Student is directed to analyse data and selects among possible conclusions | Student analyses data and draws conclusions | Analyse patterns and trends in data, and draw conclusions (VCSIS138) |
| Use knowledge of scientific concepts to evaluate conclusions (VCSIS139) | Student is given links to scientific concepts and given evaluation | Student is given scientific concepts and told how to evaluate | Student is given scientific concepts and asked to evaluate | Student is directed toward areas and sources of scientific knowledge | Student independently examines other resources and evaluates conclusions | Use knowledge of scientific concepts to evaluate conclusions (VCSIS139) |
| Communicate scientific ideas and evidence-based arguments (VCSIS140) | No communication | Student is given steps and procedures for communication | Student is provided broad guidelines to use to sharpen communication | Student is coached in development of communication | Student forms reasonable and logical argument to communicate explanation | Communicate scientific ideas and evidence-based arguments (VCSIS140) |

Several inquiry questions are possible:

1. Which brand of juice has the most citric acid content?

2. Which brand of juice has the best value for money (ratio of citric acid content to cost)?

3. Which type of juice (freshly squeezed, commercially prepared fresh juice, long-life juice, reconstituted juice, etc) has the most citric acid content?

4. Which type of juice has the best value for money (ratio of citric acid content to cost)?

5. Which type of citric juice (orange, lemon, lime, grapefruit, etc) has the most citric acid content?

6. Which type of citric juice has the best value for money (ratio of citric acid content to cost)?

7. Does the age of the juice alter the citric acid content?

8. Does the time (season) of the year alter the citric acid content?

9. Other inquiry questions are also possible.

## Inquiry versus recipe laboratory learning activities

Inquiry has several aspects, ranging from open inquiry to prescription (or recipe). See the table on the previous page [Footnote [8]].

One of the aims of the exercise is to give students an introduction to acid-base titrations, so the aspect relating to the selection and use of appropriate equipment will either be prescription or confirmation level of inquiry. Other aspects will be structured, guided or open inquiry.

## Learning outcomes

The learning outcomes of this exercise are that students should be able to

1. Formulate questions that can be investigated scientifically, with guidance from the teacher.

2. Plan, and use an appropriate investigation type to collect reliable data, with guidance from the teacher.

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[8] Based on National Research Council (2000). *Inquiry and the national science education standards: A guide for teaching and learning*. Washington DC: National Academic Press; Bruck, L. B., Bretz, S. L., & Towns, M. H. (2008). Characterizing the level of Inquiry in the undergraduate laboratory. *Journal of College Science Teaching*, 38(1), 52-58. Adapted for Victorian Curriculum by Lim, K. F. (2016), unpublished.

3. Systematically collect and record accurate and reliable data, and use repeat trials to improve accuracy, precision and reliability.

4. Construct and use a range of representations to record and summarise data from students' own investigations.

5. Analyse patterns and trends in data, and drawing conclusions that are consistent with evidence.

6. Use knowledge of scientific concepts to evaluate investigation conclusions.

7. Use a poster medium to communicate scientific ideas and information.

## Extensions

It is possible to use other experimental methods in Lessons 2-3, to investigate other scientific questions. For example, titration with iodine can be used to determine ascorbic acid (vitamin C) concentration. Potentiometric titration can be used to determine citric acid concentration in juices with more colour (eg, orange juice, lime juice, etc).

## Hypothesis versus scientific question

The issue of hypothesis versus scientific question is probably more reverent for VCE than for year 10.

The current activity only requires students to formulate questions that can be investigated scientifically; The activity does not necessarily require formulation of a hypothesis. For example, a valid question might be: what is the concentration of citric acid in ____ brand of lemon juice? However, in any investigation involving titration or any measurement, there is some confusion about the **hypothesis**. The hypothesis that juice contains 6% (or some other number) citric acid is not reasonable as there is no justification for picking a particular number.

In titration or any measurement, there is an underlying assumption that the method is fit for purpose. Instead of assuming this idea, it should be used as the hypothesis. Industrial reports and scientific papers usually have a section on the validation/calibration of the measurement method, which essentially addresses the hypothesis that the method is fit for purpose. In this situation, teachers could use the discussion in lessons 2-3 to suggest (structured inquiry) or guide (guided inquiry) students towards the following hypotheses:

1. That the chosen analytical method can be used to accurately and precisely measure the concentration of acid in a solution.

2. That the chosen analytical method can be used to measure the concentration of citric acid in juice.

In the current activity, comparisons of different juices leads naturally towards questions that are linked to hypotheses.

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