SASTA OLIPHANT SCIENCE AWARDS

SOUTH AUSTRALIAN SCIENCE TEACHERS ASSOCIATION

Prize Winner

Scientific Inquiry

Year 5-6

Daniel Maddern

Pulteney Grammar School

Better booster makes better bread: the effects of flour power on a baked sourdough loaf

Question

If I feed my sourdough starter a different booster flour before baking, will it make a better loaf of bread.

Prediction

The flour that produces the best wild yeast activity when boosting my sourdough starter will make the bread with the biggest volume, best texture, and have the best taste.

Background

I love making and eating sourdough bread. To make sourdough bread first you must make a wild yeast starter from flour and water over several weeks and use this to produce loaves of bread, instead of using commercial yeast. Part of this process means feeding the natural yeast starter each time before using it in your bread recipe. Last year my scientific enquiry was to test the power of different flours boosting or feeding the natural yeasts in the sourdough starter, to make the yeast grow and be more active. I thought that the flour with the simplest sugars would be the best. Last year I found that rye flour which had the least simple sugar had the most effect on the activity of the wild yeast allowing the starter to grow the most in volume over time. After my experiment I found out that rye contains more enzymes (amylase and maltase) that can breakdown complex sugars or starches providing a sustained source of sugar for the yeast over a longer time. This year, I would like to see if the difference between the five booster flours provides any extra benefits when using them to bake a loaf of sourdough bread.

Planning

The structure and volume of baked bread is largely due to gluten proteins (gliadin and glutenin) in flour that mix with water to form gluten strands. During baking, bubbles of carbon dioxide produced by yeasts and bacteria in the starter and water in the dough become trapped in the gluten structure causing the bread to rise. Each variety of flour contains different amounts of these gluten forming proteins so naturally these can change the structure and volume of the bread. In my experiment I want to test only the power of each flour to enhance or boost the yeast activity and therefore produce more CO_2 during the baking process then I must use only one type of baking flour to make my loaves.

The variable in my experiment are the five varieties of flour that I add to my yeast starter.

The loaves were then measured for:

- bread volume, weight and height
- by cutting the loaf in half and finger test for elasticity and springiness
- observe cross section for crumb evenness, number and size of air holes in bread
- slice the loaf and judge taste, texture and chewiness

To measure the volume of bread I found the Archimedes principle describing how an object placed in water will displace a quantity of water equal to the volume of the object, and I decided this could be used to measure the volume of the irregular shaped loaves.

However, placing a loaf of bread in a container of water and measuring the rise in the height of the water would be a problem because bread is porous and could absorb the water instead of displacing it. Other methods use fine sand or rice to pack around the object and measure displacement. I will use two methods, wrap the bread in plastic and put in a jug of water, and bury the bread in sushi rice and measuring the displacement.

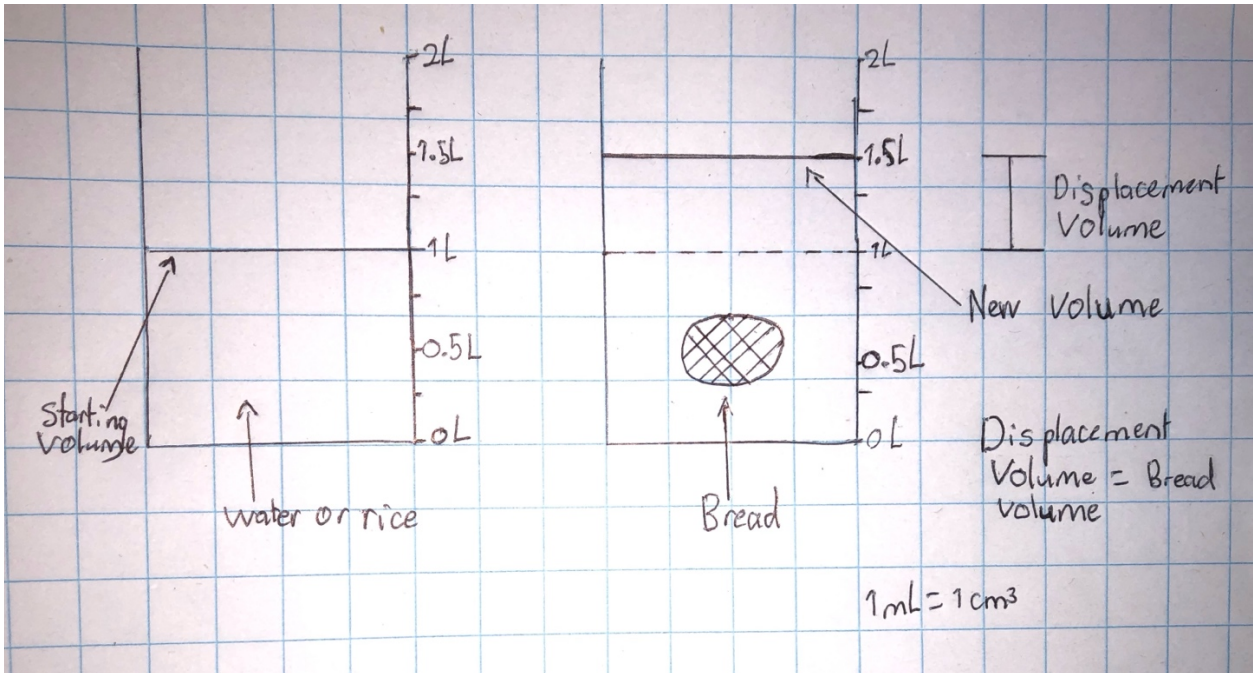


Figure 1 Archimedes Method Measuring Volume by displacement

Flour type	Brand	Protein	Carbohydrate	Sugars
White	Manildra Bakers Flour	10.7g	70.7g	1.9g
Wholegrain	Kialla Pure Stoneground Plain Flour	11.3g	64.5g	0.66g
Spelt	McKenzie's Wholemeal Spelt Flour	17g	58.6g	1.1g
Chickpea *	McKenzie's Chickpea Flour	21.9g*	47.7g	3.4g
Rye **	Kialla Pure Organic Wholegrain Rye Flour	10.9g*	75.4g	1.1g

Table 1 The flours used in the experiment, protein (including gluten proteins- gliadin and glutenin) carbohydrate (complex sugars) and simple sugars

* Chickpea protein does not contain gluten forming protein

** Rye protein called secalin and glutenin

Method

Part 1 Prepare equipment (Table 2)

Part 2 Starter

1. Remove the starter from the fridge and allow to warm to room temperature
2. Measure out five portions of yeast starter (weighing 40g each) and add to 20g of each flour, 20g of warm water to each starter and mix
3. Cover with clingfilm and label with flour variety.
4. Keep the room temperature at 22 degrees C to encourage yeast activity.
5. Measure the height of each yeast starter at time 0, 2 hours and 4 hours.

Part 3 Basic Bread Dough Method

1. Weigh the bread flour, salt, warm water and starter (Table 3), mix in a glass bowl.
2. Scoop the bread dough mixture onto a bench and knead for 10 minutes, place the dough back into glass bowl and cover with clingfilm and label.
3. Leave in a warm place for 4 hours.
4. Scoop the dough onto a bench; stretch and fold dough for 2 minutes until it's difficult to stretch, shape the dough to fit the baking container. Place dough into bowl and cover with clingfilm and refrigerate for 12 hours.
5. Remove from fridge and place the dough ball into the baking container and place into oven (preheated 220 deg C)
6. Cook until crust is golden and internal loaf temperature is 94-96 deg C measured with internal probe.
7. Remove bread from cooking pan and allow to cool
8. Measure and record the results

Part 1 (Starter)	Yeast starter (homegrown in 2024) 5 different varieties of flour (varieties chosen from science enquiry 2024) see Table 1 Cooled, boiled water 5 identical clear, colourless glasses capacity 300ml Electronic kitchen scales Metal ruler Thermometer (room)
Part 2 (dough) additional	Bread flour Glass bowls for mixing and proving Cooking thermometer with temperature probe 10kg bag sushi rice 3L and 5L clear plastic graduated measuring jugs Cardboard (Loaf Method A, C) Large cast iron camp oven Method A, C 5 identical small nonstick loaf pans Method B Scissors Protractor (Loaf Method A, C) Long thick leather gloves 60ml syringe with drawing up canula Medium sized plastic freezer bags Bread Knife and chopping board

Table 2. Equipment

	Weight per loaf		
	Loaf Method A	Loaf Method B	Loaf Method C
Yeast Starter	80g	40g	80g
Bread flour	300g	200g	350g
Salt	7g	4g	7g
Water	210g	120g	210g
Baking pan	Round cast iron pan (freeform shape)	Small nonstick loaf pan	Round cast iron pan (freeform shape)

Table 3. The weight of starter, bread flour, salt and water for each loaf experiment

Experiment Results

Bread Loaf A (freeform loaf cooked in camp oven) Baking time 60min

	0 hr	2 hr	4 hr
1.Rye	5	6.5	8
2.White	5	5.5	7.0
3.Wholemeal	5	6.0	6.5
4.Spelt	5	6.0	6.5
5. Chickpea	5	6.5	7.5

Table 4.1 The height of the yeast starter after feeding (cm)

Flour	Height (cm)	Weight (g)	Volume*
1.Rye	13	577	X
2.White	12.5	558	X
3.Wholemeal	13	561	X
4.Spelt	12.5	571	X
5.Chickpea	12.5	591	X

Table 4.2 The height, weight and volume of the bread loaf

* Volume measure was unsuccessful due to wrong container

Cross Section	Crust	Texture	Crumb	Taste
	Golden-Brown Crisp Rough Split	Slightly springy	Large Air Bubbles Medium Bubbles Uniform	Nutty chewy
	Light colour Smooth Glossy	Spongy and springy	Dense Fewer Bubbles Fine Bubbles	Sweeter soft
	Golden-Brown Crisp Rough Split	Springy but tough	Medium Bubbles Uniform Throughout	Nutty chewy
	Light colour Smooth Glossy Bubbly Blisters	springy	Large Air Bubbles Medium Bubbles Uniform	No taste
	Split single Smooth Semi-Split Glossy	Spongy and springy	Dense Few Bubbles	Slight taste chickpea Sweet, soft

Table 4.3 The characteristics of the bread Loaf A

Bread Loaf B (rectangular loaf cooked in loaf pan) Baking time 40min

	0 hr (cm)	2 hr	4 hr
1.Rye	5.	6	8.0
2.White	5	6.5	7.5
3.Wholemeal	5	6	7.5
4.Spelt	5	6	7.5
5. Chickpea	5	6	8

Table 5.1 The height of the starter after feeding (cm)

Flour	Max height (cm)	Weight (g)	Volume(ml/cm3) water method
1.Rye	11	409	705
2.White	12.5	412	800
3.Wholemeal	10.5	399	710
4.Spelt	12	408	720
5.Chickpea	11.5	406	780

Table 5.2 The height, weight and volume of the bread loaf B

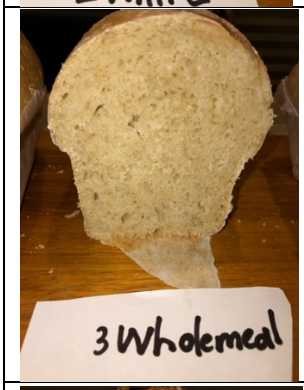
Cross Section	Crust	Texture	Crumb	Taste
	Dark, golden colour, no cracks	Firm, elastic	Large air bubbles, even throughout	Nutty peppery
	Smooth with light golden colour	Spongy, soft	Medium air bubbles around crust	sweet
	Smooth with light Golden colour	Firm, elastic, chewy	Medium air bubbles	Nutty
	Smooth, medium golden coloue with 2 cracks	Firm, chewy	Large air bubbles under crust	Nutty & sweet
	Smooth medium golden colour with 1 crack	Spongy, soft	Medium air bubbles throughout	Can taste and smell a little chickpea sweet

Table 5.3 Characteristics of the Bread Loaf B

Bread Loaf C (freeform loaf cooked in camp oven) Baking time 60min

Flour	0 hr	2 hr	4 hr
1.Rye	4.5	7.5	9
2.White	4.6	6	7.5
3.Wholemeal	4.5	6	7
4.Spelt	4.5	5.8	7
5. Chickpea	4.5	6.5	8

Table 6.1 The height of the starter after feeding (cm)

Flour	Height [cm]	Weight [g]	Volume [ml/cm3] water	Volume [ml/cm3] rice
1.Rye	13.5	550	1012	1050
2.White	11	538	1100	1100
3.Wholemeal	13	559	1025	1050
4.Spelt	13	547	1060	1000
5.Chickpea	12.5	573	1105	1120

Table 6.2 The height, weight and volume of the bread loaf

Cross Section of Loaf	Crust	Texture	Crumb	Taste
	Three large cracks, light golden colour	Dense, less springy	Large air bubbles throughout	Nutty, chewy, peppery
	Smooth with big wrinkles,Dark golden colour	Very soft and spongy	Medium air bubbles under crust Other parts have fine bubbles	Sweet [soft in mouth]
	Smooth,light golden colour	Elastic, firm, tough	Medium air bubbles even throughout	Nutty
	Medium golden colour one crack, smooth	Soft, spongy	Large air bubbles under crust	No taste
	Dark golden colour,smooth	Soft, springy	Medium air bubbles under crust fine bubbles throughout	Mild chickpea taste and smell chewy

Table 6.3 Characteristics of Bread Loaf C

Discussion of Results

The effect of the 5 test flours on the activity of the starter was the same as last year, Rye produced the most growth followed by Chickpea flour.

The bread height results showed in free form loaves rye and wholemeal were the highest but in the loaf pan bake white flour was the clear winner.

In the test of bread volume, white flour produced the biggest volume followed by chickpea, then spelt, wholemeal and rye.

The taste and texture results were different for each bread. Some in our family liked the chewy, nutty rye and wholemeal and others preferred the soft, spongy and sweet white bread and earthy chickpea

This experiment shows:

- The difference in bread volume with the different booster flours is small less than 100cm3 and the crumb of the bread (with its airholes) looked very similar between the loaves
- Adding small amounts of different flours to the yeast starter (about 5 -9% of final flour volume for the bread) can have a large effect on the texture and taste of the bread

My prediction that the rye flour would produce a larger bread volume was incorrect as white flour won. Rye (a super food for yeast) with less gluten proteins may hinder baking a large loaf. In my research, I found adding salt to bread improves taste but also slows down yeast growth and might hinder the rye enzymes (amylase) that free up sugars for the yeast.

Problems

Measuring the large freeform shape loaves in Method A & C was difficult. The measuring containers I used were not very accurate.

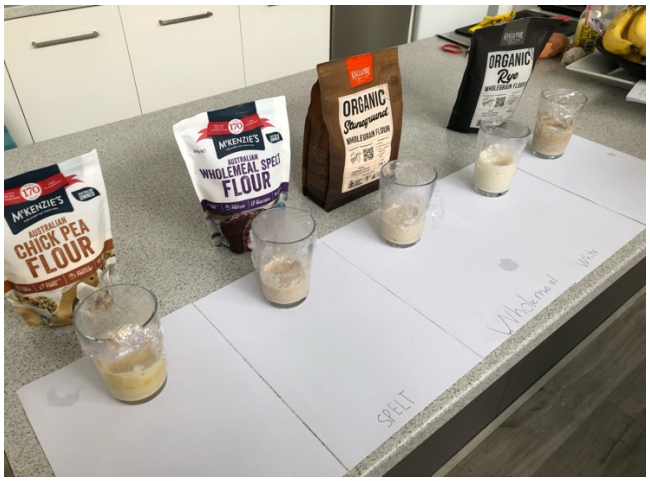
Summary

My experiment has challenged me to find methods at home to measure the volume of bread loaves. Judging bread quality is opinion based and we need to ask the question “is my best bread, your best bread”?

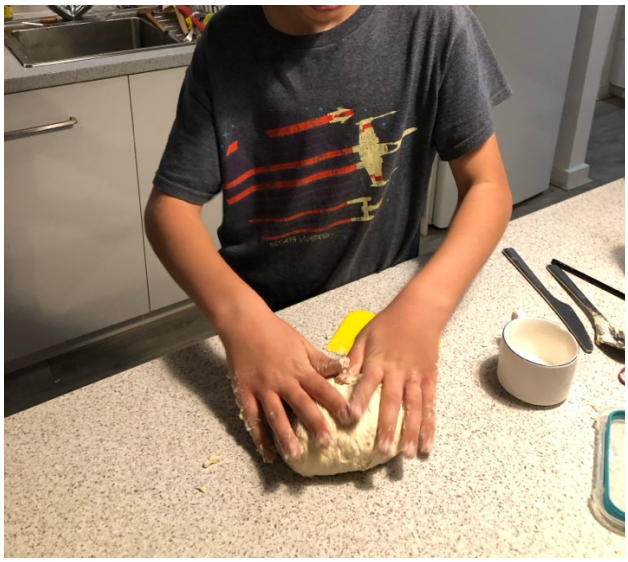
Word Count (1092)

Acknowledgements - Dad for helping with baking the bread, lifting heavy cooking pans and testing the temperature. Mum for helping with photos (taking some photos, downloading and editing them and for helping edit my report and with the tables.

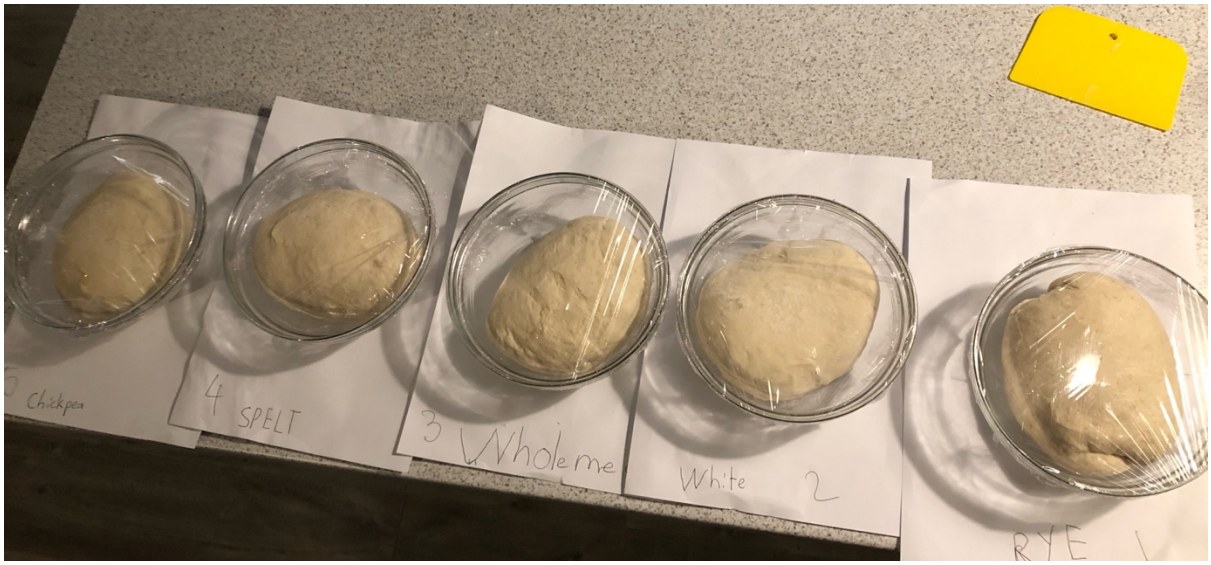
Photos of each stage



Feeding the yeast starters (growth phase)



Kneading the bread dough



Resting the bread dough (room temp 22 deg C for 4 hours)

Preparing the dividers for use in camp oven in Bread Loaf A & C

Dough ball in camp oven before baking

Measuring the bread
Top left – measuring the height
Bottom left – measuring the volume with rice
Above – measuring the volume with water

References

Maddern, D. 2024 The effect of flour power on sourdough yeast. https://www.oliphantscienceawards.com.au/the_oliphant_science_awards/2024-online-project-gallery/scientific-inquiry

Chin, T. 2023 The Best Flour for Sourdough Starters: An Investigation. Serious Eats https://www.seriouseats.com/the-best-flour-for-sourdough-starters-an-investigation

Anastopoulos, R. 2021 A beginner's guide to Gluten. King Arthur Bakinghttps://www.kingarthurbaking.com/blog/2021/08/18/a-beginners-guide-to-gluten

Lesson 4: Finding the Volume of Irregularly shaped Objects https://www.friendlyphysicalscience.com/FriendlyPhysicalScienceL4.pdf

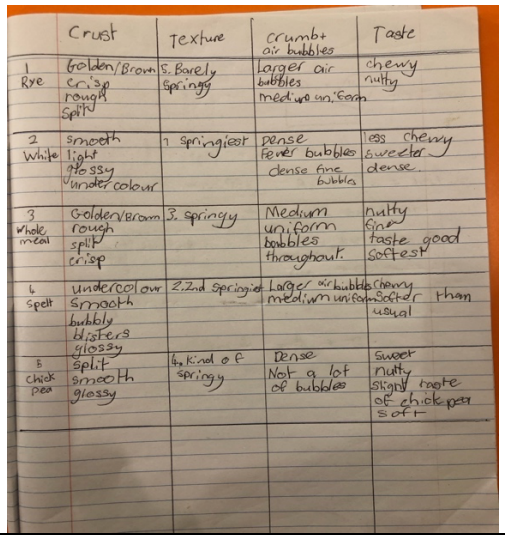
Tai, A. 6 Reasons Rye is Popular in Sourdough & What to Know Before Using it https://truesourdough.com/6-reasons-rye-is-popular-in-sourdough-what-to-know-before-using-it/

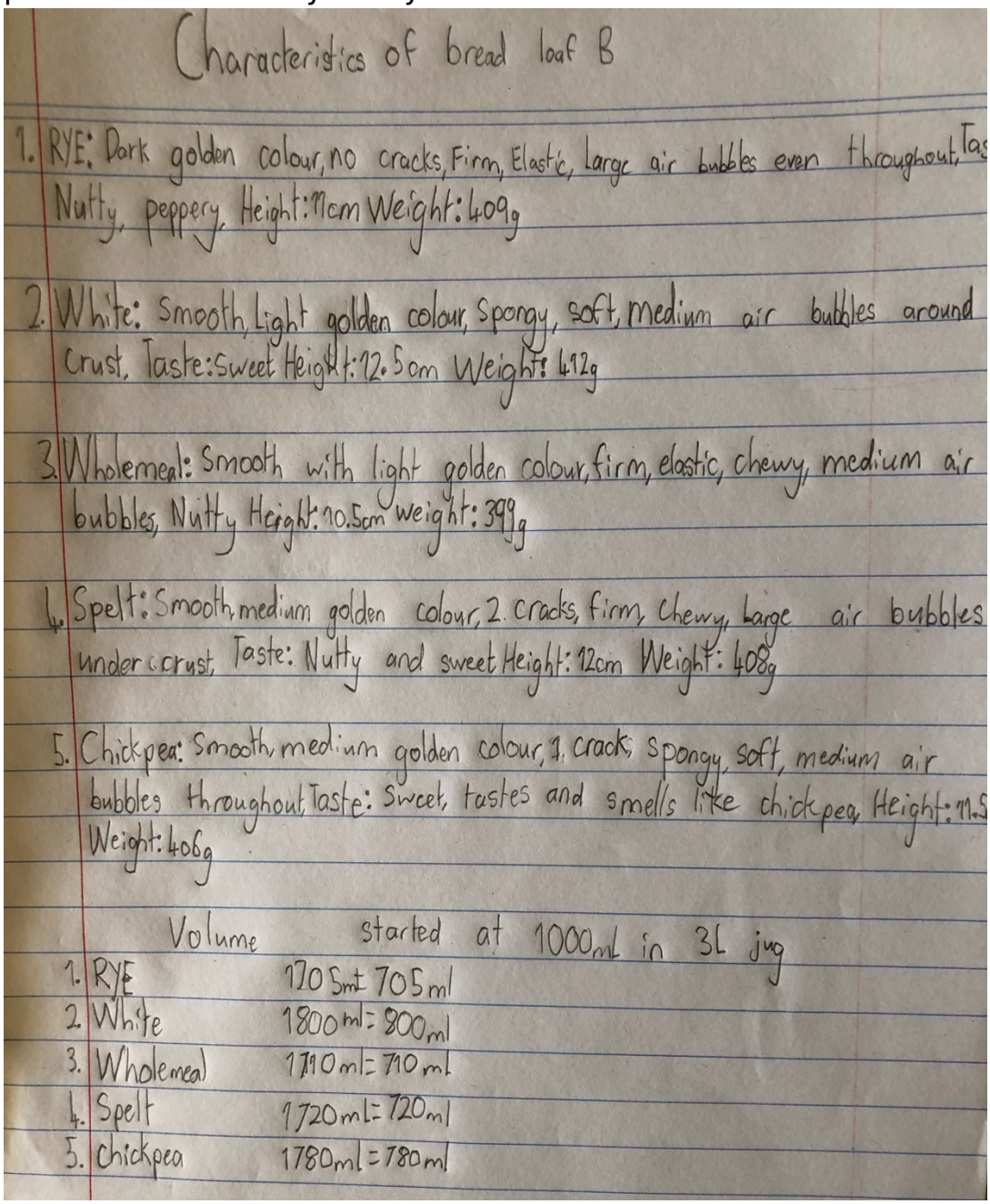
Kihm, H. 2016 The Science Behind.... regulating Enzyme Activity in Rye Breads. The Bread Maiden https://thebreadmaiden.com/2016/06/18/the-science-behind-regulating-enzyme-activity-in-rye-breads/

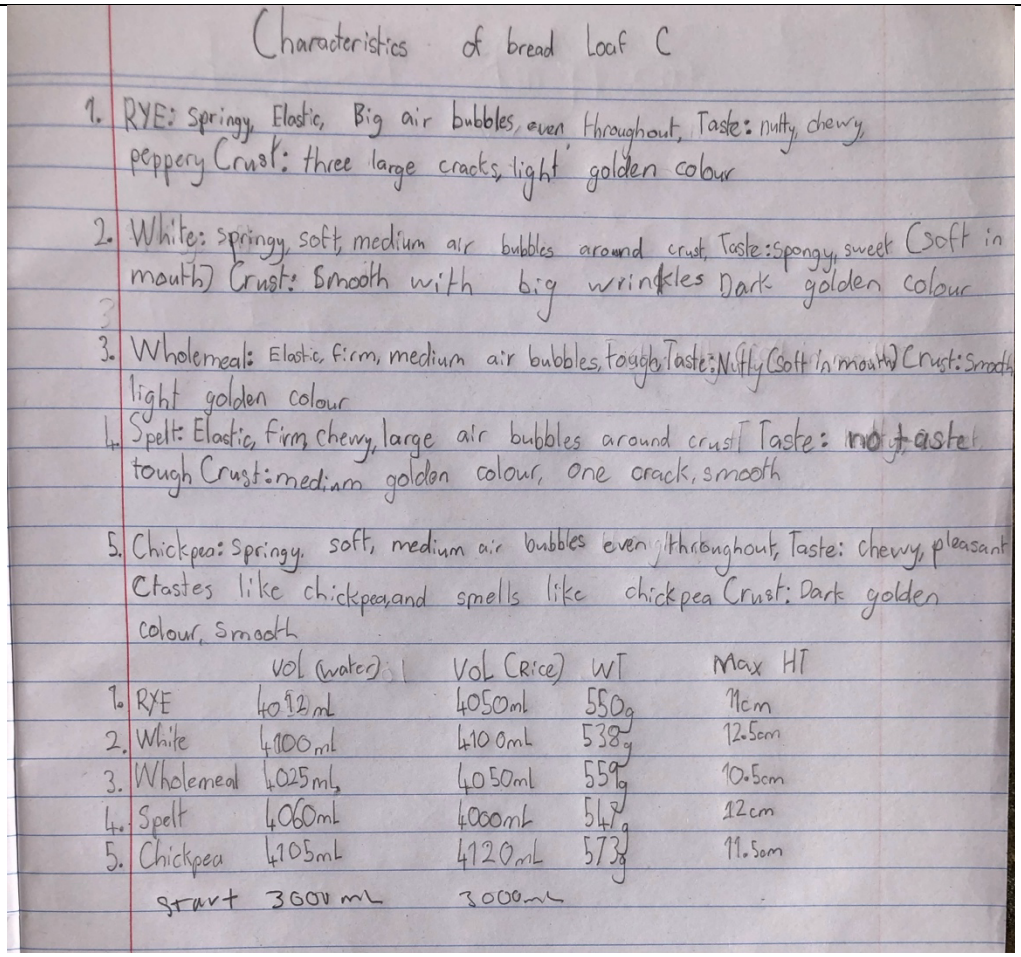
Scientific Enquiry Daniel Maddern ID: 0529-003

Logbook for Sourdough Experiment (including raw data)

October 2024	My dad put our sourdough yeast starter in the freezer; we don't bake bread over summer as we are too busy on weekends. If you leave the yeast starter in the fridge it still needs attention and weekly feeding with flour otherwise the balance of yeast and bacteria changes; it can become too acidic or go mouldy. Freezing is a good way to preserve the yeast by putting it into hibernation.
29/3/25	I started planning my experiment by reading about how gluten content affects the structure of bread. There are lots of websites but the one I found most useful was A beginner's guide to Gluten. King Arthur Baking Dad suggested I could bake the bread loaves with the 5 different flours, but I know that I would be comparing the different gluten proteins amounts in flours and not the difference in yeast activity. The chickpea flour with no gluten and would bake as a flat disc. I thought about the amount of the test flours I am using to boost my yeast starter. Chickpea flour does not contain these gluten proteins and rye flour contains a different gluten protein called secalin so will this affect my bread structure at the end of the bake? My solution was estimating the amount of test flour as a percentage of total flour used to bake the bread Thinking about the method of my experiment; we have a lot of equipment from last year and I only need to buy mixing bowls and baking pans.
2/4/2025	Mum bought me some new flour., the same brands as last year. The bread pans and mixing bowls were ordered online.
24/5/25	Dad took the yeast starter out of the freezer. I left the starter to thaw completely for 24 hours on the bench at room temperature, then I fed the starter 40g of white bakers' flour and added some warm water, left it at room temp for 12 hours, then put it in the fridge
30/5/25	I fed the starter again with white flour/water and returned it to the Fridge
1/6/25	First Bake - Dad baked a loaf of sourdough with the starter. It looked and tasted good.

9/6/25 10/6/25 June long weekend	I planned to bake this weekend so I could work through the day without being interrupted with sport. Problems - I started late (after lunch) which meant with all the steps plus the dough rest time I finished at 9pm and we had to find enough space in the fridge for the glass bowls to rest overnight.
10/6/25	I baked the loaves the next morning, I found a way to build dividers in the pan with cardboard and a protractor to measure the angles of the 5 divisions, but the baked bread stuck to the dividers, so I decided that I need to flour it next time. I wanted to measure the bread volume with sushi rice because the grains are rounded and would pack evenly each time; because of hygiene we could eat the bread after it had been buried in the rice. Measuring bread volume using the sushi rice was messy and the container didn't have enough markings on it to measure. displacement volume of the bread loaf. After I measured the weight and height, Mum cut the bread and I took photos of the cross section of the bread, and I judged the bread in for crumb, colour, texture, taste.  Crust / Texture / crumb+ air bubbles / Taste 1 Rye — golden/Brown, crisp, rough, split — 5. Barely springy — Larger air bubbles, medium uniform — chewy, nutty 2 White — smooth, light, glossy, under colour — springiest — dense, fewer bubbles, dense fine bubbles — less chewy, sweeter, dense 3 Whole meal — Golden/Brown, rough, split, crisp — 3. springy — Medium uniform bubbles throughout. — nutty, fine, taste good, softest 4 Spelt — undercolour, smooth, bubbly, blisters, glossy — 2. 2nd springiest — Larger air bubbles, medium uniform — chewy, softer than usual 5 chick pea — split, smooth, glossy — 4. Kind of springy — Dense, Not a lot of bubbles — sweet, nutty, slight taste of chickpea, soft
11/6/25	I filled out the risk assessment form and got my science teacher Mrs Cox to sign it. I started writing up my experiment and uploading photos, I was worried about the word count until mum showed me the rules. It needs a lot of editing.
12/6/25	Mum bought some new clear plastic jugs so that the bread loaf volume could be measured, there is a 3L jug for small loaves and a 5L jug for larger loaves, the volume markings on the jugs are much clearer. Mum gave some suggestions on how to organise my report because it's difficult to have one basic way to start and then split it into 3 different baking experiments, so I have now called the first bake Loaf Method A.

14/6/25 15/6/25	Loaf Method B, I started the experiment on Saturday and finished on Sunday using much smaller quantities of baking flour so I could make smaller loaves to fit into the loaf pans. I can measure these smaller loaves better by water and rice displacement methods using the new graduated jugs. It worked well but the loaves had soft sides, protected by the loaf pan and were not very crusty.  Characteristics of bread loaf B 1. RYE: Dark golden colour, no cracks, Firm, Elastic, Large air bubbles even throughout, Tas Nutty, peppery. Height: 11cm Weight: 409g 2. White: Smooth, Light golden colour, Spongy, soft, medium air bubbles around crust. Taste: Sweet Height: 12.5cm Weight: 412g 3. Wholemeal: Smooth with light golden colour, firm, elastic, chewy, medium air bubbles, Nutty Height: 10.5cm weight: 399g 4. Spelt: Smooth, medium golden colour, 2 cracks, firm, Chewy, Large air bubbles under crust, Taste: Nutty and sweet Height: 12cm Weight: 408g 5. Chickpea: Smooth, medium golden colour, 1 crack, Spongy, soft, medium air bubbles throughout Taste: Sweet, tastes and smells like chickpea, Height: 11.5 Weight: 406g Volume started at 1000ml in 3L jug 1. RYE 1705ml 705ml 2. White 1800ml = 800ml 3. Wholemeal 1710ml = 710ml 4. Spelt 1720ml = 720ml 5. Chickpea 1780ml = 780ml
17/6/25	Record 2 sets of results Loaf A and Loaf B. Next time I will record all my results in the same book and work more at organisation before I start.
21/6/25 22/6/25	Prepared and baked Loaf C The crusts of all loaves look softer, and the crumb is more open. This time I measured the volume using both the rice and water method.

	 Characteristics of bread loaf C 1. RYE: Springy, Elastic, Big air bubbles, even throughout, Taste: nutty, chewy, peppery Crust: three large cracks, light golden colour 2. White: springy, soft, medium air bubbles around crust, Taste: Spongy, sweet (soft in mouth) Crust: Smooth with big wrinkles Dark golden colour 3. Wholemeal: Elastic, firm, medium air bubbles, tough, Taste: Nutty (soft in mouth) Crust: Smooth light golden colour 4. Spelt: Elastic, firm, chewy, large air bubbles around crust Taste: nutty taste tough Crust: medium golden colour, one crack, smooth 5. Chickpea: Springy, soft, medium air bubbles even throughout, Taste: chewy, pleasant (tastes like chickpea and smells like chickpea Crust: Dark golden colour, Smooth vol (water) Vol (rice) WT Max HT 1. RYE 4012 mL 4050mL 550g 11cm 2. White 4100 mL 4100mL 538g 12.5cm 3. Wholemeal 4025mL 4050mL 559g 10.5cm 4. Spelt 4060mL 4000mL 547g 12cm 5. Chickpea 4105mL 4120mL 573g 11.5cm start 3000 mL 3000mL The volume results are looking like my prediction has failed. Reading effort is needed to explain why rye is not working better in bigger bread volume. All the loaves look similar both in size and crumb, the volume measurement is about 100ml/cm3 between largest and smallest (not much difference)! After judging the bread, mum sliced up all the loaves and put the bread in the freezer.
23/6 -27/6	Writing my report, Mum is helping airdrop and insert the photos. I am putting a lot of information into tables to organise and format it better.
28/6/25	Final read, edit and word count. Checking for bookmarked websites to write in my references. Still deciding if need to put my results in bar graph
29/6/25	Mum uploaded my project to OSA online

OSA RISK ASSESSMENT FORM

for all entries in (✓) ☐ Models & Inventions and ☐ Scientific Inquiry

This must be included with your report, log book or entry. One form per entry.

STUDENT(S) NAME: Daniel Maddern ID: _____

SCHOOL: Putney Grammar School

Activity: Give a brief outline of what you are planning to do.

Adding flour to sourdough starter and using this to bake loaves of bread. Measure the size of the loaves, and then cutting them open and tasting them.

Are there possible risks? Consider the following:

- Chemical risks: Are you using chemicals? If so, check with your teacher that any chemicals to be used are on the approved list for schools. Check the safety requirements for their use, such as eye protection and eyewash facilities, availability of running water, use of gloves, a well-ventilated area or fume cupboard.
- Thermal risks: Are you heating things? Could you be burnt?
- Biological risks: Are you working with micro-organisms such as mould and bacteria?
- Sharps risks: Are you cutting things, and is there a risk of injury from sharp objects?
- Electrical risks: Are you using mains (240 volt) electricity? How will you make sure that this is safe? Could you use a battery instead?
- Radiation risks: Does your entry use potentially harmful radiation such as UV or lasers?
- Other hazards.

Also, if you are using other people as subjects in an investigation you must get them to sign a note consenting to be part of your experiment.

Risks	How I will control/manage the risk
Using warm water	measure temperature of water parent to help
Accidently contaminating my mixture, myself, Enviroment	wash my hands on utensils before and after use.
Baking bread in hot oven	Getting parent to help remove baking pan from oven.
Cutting loaves of bread to taste.	Being careful with knife, asking parents for help

(Attach another sheet if needed.)

Risk Assessment indicates that this activity can be safely carried out

RISK ASSESSMENT COMPLETED BY (student name(s)): Daniel Maddern

SIGNATURE(S): DM

☑ By ticking this box, I/we state that my/our project adheres to the listed criteria for this Category.

TEACHER'S NAME: Robyn Cox

SIGNATURE: _____ DATE: 11/6/25