Science Fair Logbook

Can AI Replace Fruit Stickers?

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Section One: Acknowledgements & Citations

Through this project, we had lots of help and received advice from many people. We would like to start by thanking our wonderful parents for helping us in times of need, and giving us advice. We'd also like to thank our teacher, Heather Lai, and Westmount Charter Mid-High, who arranged and planned the school Science Fair. We would like to acknowledge CYSF staff for hosting this event, and all the judges who judged and will judge our project. We would also like to thank all the sources and websites that we used for our research: Viso AI, The Ledger, CBC, EcoEnclose, Elevate Packaging, NPR, Google, IFPS Global, Vinyl Pressing, Sustainable Packaging, Nature's Path, PLU Finder, Situ Biosciences, Cosmos Magazine, Dirt-mag, and Modern Farmer. Thank you so much to everyone for everything that they did to help us through this project!

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Section Two: Timeline

Sunday, October 13th, 2024:

Decided on topic

Research - Note taking on PLU stickers

Logbook creation

Monday, October 14th, 2024:

Researching

Tuesday, November 5th, 2024:

Logged into CYSF

Saturday, November 16th, 2024:

Researching

Filled out information in CYSF website

Friday, November 29th, 2024:

Researching, planning

Saturday, November 30th, 2024:

Planning, filling out forms in CYSF

Sunday, December 1th, 2024:

Testing what pictures need to be taken, planning set-up, taking pictures

Saturday, December 7th, 2024:

Researching

Saturday, December 14th, 2024:

Uploaded pictures to AI platforms

Monday, December 23rd, 2024:

Analyze pictures, continuing logbook

Sunday, December 29th, 2024:

Filling in logbook, analyzing results, sorting pictures

Monday, December 30th, 2024:

Sorting images, filling in logbook

Tuesday, December 31st, 2024:

Putting research in paragraph form, filling in logbook, started slideshow, sorting images

Thursday, January 2nd, 2025:

Filling in logbook, organizing research, sorting images, starting slideshow

Monday, January 6th, 2025:

Slideshow

Tuesday, January 7th, 2025:

Working on logbook, citations, slideshow

Wednesday, January 8th, 2025:

Logbook

Monday, January 13th, 2025:

Logbook, slideshow

Wednesday, January 15th, 2025:

Logbook, slideshow, filling in CYSF

Friday, January 17th, 2025:

Logbook, slideshow

Saturday, January 18th, 2025:

Slideshow, logbook

Sunday, January 19th, 2025:

Logbook

Monday, January 20th, 2025:

Logbook

Tuesday, January 21st, 2025:

Logbook

Wednesday, January 22nd, 2025:

Logbook

Friday, January 24th, 2025:

Logbook

Saturday, January 25th, 2025:

Logbook

Sunday, January 26th, 2025:

Slideshow, logbook

Monday, January 27th, 2025:

Slideshow

Tuesday, January 28th, 2025:

Slideshow, logbook

Wednesday, January 29th, 2025:

Slideshow, logbook, submitting stuff in CYSF, starting to plan trifold

Thursday, January 30th, 2025:

Logbook, Slideshow, trifold

Friday, January 31st, 2025:

Logbook, trifold, five page summary, table of contents, submitting stuff in CYSF

Saturday, February 1st, 2025:

Logbook, trifold, CYSF

Sunday, February 2nd, 2025:

Trifold, practice

Monday, February 3rd, 2025:

Trifold, practice, logbook

Section Three: Question

Can Artificial Intelligence (AI) be used to identify fruit, instead of using plastic PLU codes on stickers?

Section Four: Background Research and Data

Outline:

This project will cover solutions to plastic fruit stickers by using Artificial Intelligence. We took pictures of fruit and imputed this information in an AI software and recorded the results. We are hoping to give an idea of what we could use in the future, instead of stickers. We wanted to prove that the idea works, with some adjustments that are needed.

We wanted to do this project because we are passionate about nature and the health of our planet. When we found out about the billions of stickers going into the landfills, from a news article, we decided to step up and do something. We had pondered for months, wondering what we were going to do. One day we were playing with Google Lens, an AI software that is built into most smartphones, taking pictures of things and seeing the results it gives. Then we got the idea to use AI to identify fruits! Right away we got started on our experiment.

In this project we are going to cover what we researched, how we set up our experiment and the procedure, and the results it gave.

Our controlled variable is our setup (the trifold, table, metal baking pan, lighting, phone position, phone holder). We wanted to make sure each picture was the same, since in the fruit scanner in grocery stores, it does not move and each picture is the same. In our setup, we made sure to not move the table or trifold and especially the phone holder. We luckily had a phone holder available and it was stiff, perfect for our experiment. As we took the pictures, we made sure that the phone didn't move or shake.

Our manipulated variables are the fruit types, variety, different types of grocery bags, angles, and AI softwares. We wanted to make this experiment as real as possible to the real life machine- the fruit scanner- by setting up our experiment to look like it. We had a metal baking pan, for the weight scanner, a white trifold as the modern grocery store background, and a phone on a stand to act as the camera or scanner. On the other hand, we also wanted the fruit variables to be the most realistic too. Customers putting fruit on the scanner are not going to place it the exact same way. Taking this into consideration, we adjusted the angle of the fruit for each picture and added a bag or not. (ex. Clear grocery bags). We also adjusted the quantity of our fruit. But most importantly, there are different types! When we started our experiment we bought many common fruits and the different variety within them. For example, we bought apples, bananas and mangos, but also Cosmic Crisp, Red delicious, and Granny Smith apples. And we took pictures of all of them.

Our responding variable was the results we got from the AI software. We wanted to see if the AI could identify which fruits or which variety. Our hypothesis was: We think that Artificial Intelligence will be able to identify some obvious fruits, but not different variety of fruit. We used two different AI softwares: LogMeal and Google Gemini. Google Gemini is a software programmed by Google and LogMeal is a software that is meant for identifying foods in general. We will measure it by seeing how close the AI was to the actual fruit. This will give us the answers we need in order to find out if this method that we are testing, actually works, or if it needs some programming.

We discovered that Google Gemini actually had pretty close results to the actual fruit, and it tries to label the variety type too. LogMeal is just categorizing the images and is not labeling the variety. It only labels the type of fruit. (ex. Apple, banana, orange).

In conclusion, we found out from our experiment that Google Gemini had close results and identified most fruits exactly, while LogMeal didn't. These results can help us stop plastic pollution in the ocean and soil and help us live a better life with Mother Earth. Artificial Intelligence can identify some fruit types, though it may need to be programmed and taught more to be able to identify just produce, instead of a wide variety of objects. This might help AI be better at identifying fruits and vegetables and could one day be in stores.

Research:

Reasons:

The fruit consumption in Canada per year in 2022 is 5,000,000 average apples, which means, 33,000,000,000 stickers, that end up going into landfills and collecting.

Vinyl takes up to 1000 years to decompose, like plastic.

Plastic eventually breaks down and keeps breaking down until they are micro sized hence the name micro plastics. These get in the water and ground, and affect animals because they could mistakenly eat it for food, accidentally swallow it, or ingest it by **trophic transfer, meaning that if another animal eats that animal, they could ingest the plastics too.** Animals could get very sick and die from it.

In our home compost, fruit stickers tossed away by the previous owner were still clearly visible and intact from 20 years ago. The ink and words were still readable.

Compostable sticker designs are twice as much as plastic stickers
You need the world to adapt to change. If only one company makes compostable stickers, you need the whole world to make a difference. Because of low demand, it is likely that these compostable stickers will only be popular once people recognize it. This could take a while, since people haven't realized, or are ignoring the harm it does.

Compostable stickers are not yet widely recognized as an unnecessary single-use plastic. There is a "lack of demand and production".

In Washington, facilities identified non-compostable produce stickers as one of the top five things that come up.

Composting has lots of benefits for the environment, including helping to divert food waste out of landfill, where they make methane. Composting helps other things grow, because of the nutrients that were once natural things that got tossed in the soil.

By addressing one of composters' biggest contaminants, the compostable packaging and produce industries would be supporting the profitability and viability of the composting industry. This would help create a more positive relationship between groups, demonstrating care for the quality of finished compost, and serve as an example for other compostable products.

In 2017, a Washington State Organics Contamination Reduction Workgroup report determined that "although compostable stickers were made and working, it has not yet reached a demand to

take over plastic stickers". Since that time, the landscape of manufacturers has not changed their ways, although more retailers have trialled solutions. Presumably, this means that today's compostable produce stickers are also cost-prohibitive. As more solutions come on the market and are adopted more widely, they become more cost-effective to manufacture.

Bans on plastic produce stickers are set to go into effect, consumers are likely to grow increasingly frustrated, and composters may become **stricter** about not accepting stickered food waste.

- Compostable products will break down within the time needed by the composting environment and will not release harmful residues.
- Biodegradable products have no such definition, and the term is not regulated.
- Eco friendly terms can also be used to imply that a product is good for the environment when it is not.

Plastic Stickers:

Used on a variety of produce, the stickers are helpful at checkout because they carry important information: price look-up codes, or PLU codes. The International Federation for Produce Standards determines these PLU codes, which have been in use since 1990, with 1400+ codes assigned.

They cannot be removed with the equipment that is often used to remove other types of contaminants, such as Trommel screens or depackaging equipment

Produce stickers are also a very common contaminant in the residential food waste stream, since consumers may not remember to remove them from peels and skins, or they didn't bother.

In the case of grocery store food waste, plastic produce stickers make it challenging to accept and process large quantities of off-spec or spoiled produce. This can result in truckloads of produce being turned away from composting facilities and instead sent to landfills.

Countries are attempting to change this. France became the first country to put a law in effect. They will not allow any more plastic produce stickers. This law will go into effect on January 1, 2022. In the United States, a proposed ban on non-compostable produce stickers is included in the proposed Break Free From Plastic Pollution Act In New Zealand, the Auckland City Council has also proposed a ban on non-compostable produce stickers.

Scott Amron the inventor of the 'Brush and Rinse Toothbrush' invented the dissolving soap fruit stickers. The project was called 'Fruit Wash'. He wanted something that could still work as a barcode but have some other purpose that is okay for the environment. The stickers dissolve into

a soap to clean fruit or vegetables from wax, pesticides or dirt, when in running water. Scott Amron made them so they still stick. It is made of 'natural or organic' ingredients. (Won't label what it is made of).

- Food experts say that the fruit soap stickers don't clean much better than just plain water

In 2007, researchers at the Institute of Agricultural and Environmental Sciences at Tennessee State University tested the stickers on both diluted vinegar and plain water. Sandria Godwin, who oversaw the project says that the stickers were not necessary nor effective. After the experiment, Sandria Godwin says that she still thinks that scrubbing with water is the best way to clean fruit, but she likes the idea of 'no waste' stickers.

- The US Centers for Disease Control and Prevention also agrees that washing the fruits with water is best.

The stickers also tell the PLU or 'price look up' on a fruit. Because of that, it makes the inventory check-out easier, speeds up the process and the cashier doesn't have to remember stuff.

- Don't eat the stickers. This led to someone eating it by accident and having a really long cough and lung infection, until they removed it after two years.
- The stickers won't break down in a composting facility. The fruit would essentially 'melt' in the heat, but the stickers would not break down because of plastic. The stickers can make it through the whole process of composting things (shredder, heat, and filter)
- The filter, which was ⅛ of an inch, didn't even catch any stickers.

Structures and Materials:

The fruit stickers are made of vinyl plastic, though sometimes paper is used. This is so that the stickers are water-resistant, and are not damaged by packing and transit, but they are also not compostable or recyclable. The glue is non-toxic and edible, and leaves no residue on the fruit.

Other Designs:

Laser Imprinting:

Add both letters and images to a piece of fruit or vegetable by removing the pigment from the peel's outer layer. It is a superficial process that does not affect the product's flavor, aroma, or shelf life, and the laser-tagged part remains edible. According to the EU-funded project, laser labeling could actually be faster than the standard method.

In 2016, Netherlands-based laser technology company Eosta and Swedish supermarket ICA ran a trial of organic fruit and vegetables with natural branding, which they claimed replaced millions of pieces of plastic packaging. Around the world countries are making the switch.

The Oregon State University Food Innovation Center developed a laser imprinting system that imprints a code on the fruit. They burn a print on the skin of a fruit. They work on a wide range of produce.

- These laser prints avoid the use of glue, plastic, and inks on fruits.
- The lasers etch the brand, variety, and a code, similar to a QR code but different than the normal barcode, on the fruit. These are about the same size as an actual fruit sticker.

Process:
The produce goes on a conveyor belt and in the middle there is a sensor/scanner. It scans the fruit and then burns a mark on the fruit. The fruit is not damaged and the shelf life is the same.

Cons:
It requires a huge change that most people cannot afford nor think that it is quite as efficient. Laser printing is not suitable for delicate produce. Some of the laser printing technologies may not work on oranges, grapefruit, lemons, etc, because of their skin, which **may recover from the burn, by healing and covering the burn**. It is possible to fix this by spraying liquid on the fruit skin after the mark has been made by the laser to trigger a reaction that becomes visible.

Ink-Printing:
Printing ink on the fruit or vegetable directly, avoids the cost of materials and adhesives. Vegetable ink-based tattoos are considered safe and do not pose any health concerns. Capexo in France, has developed a process for printing food-grade ink, that works for most fruit. It works well for fruits and vegetables with a relatively smooth skin, such as mangoes. This technology would not work as well for other types of more rough Since technology is advancing with robots and AI, we feel that using AI to identify fruits in our experiment would fit into the AI dominance. It was something that we had readily available to us, and certain platforms were free to the public. AI is already in lots of places that you may not think of, including healthcare, transportation, education, and Google Maps, and does many things. For example, in healthcare, AI analyzes the patient's medical history, and tells whether or not the patient is healthy, and if there is any risks, such as pineapple or avocado. They are not water-proof, and could potentially rub off, when in contact with water.

Compostable Stickers:
Compostable produce stickers are not yet widely available. However, at least two manufacturers have market-ready compostable produce stickers. In 2015, Elevate Packaging, a sustainable

packaging and label technology company, entered into an exclusive distribution agreement for North America with Bio4Life, a Dutch company that produces compostable adhesive products and labels under the brand name PURE Labels

Sinclair, a large produce labeling company, has been trialing compostable stickers since 2008, and produced its first 100% certified compostable sticker, called EcoLabel, in 2019

Compostable stickers design:

PURE Labels compostable stickers are both biodegradable and compostable. Their performance is almost exactly the same as their plastic counterparts. Their products are made of cello and are ASTM D6400 compliant.

Types of adhesives:

- **Pressure Sensitive Adhesive**
  Pressure sensitive adhesive. This adhesive bonds/sticks when pressure is applied.
  Ex. Stickers, household tape, bandaids.
- **Hot Melt Adhesive**
  This type sticks when moisture or liquid is removed. For example when water evaporates.
  Ex. School Glue.
- **Drying Adhesive**
  Usually a plastic, which is melted and then cooled, which forms a hard, strong bond.
  Ex. Hot glue gun.
- **Reactive Adhesive**
  When a substance or chemical is applied to this, it forms a bond. Most commonly is water activated adhesives. Water is applied, and the material is usually a plant starch.
  Ex. An envelope when you lick it and seal it.

Compostable Adhesives:

Some are made with animal proteins, or plant proteins.

AI:

Artificial Intelligence is a collection of technologies that allow computers to perform tasks that normally need human intelligence to be done, such as learning, reasoning, problem solving, and interacting with others. AI uses algorithms, data, and more to simulate human intelligence, allowing them to do their job. AI systems can learn from experience and improve their performance, a critical part of their programming. Data is crucial in the programming and learning process of AI, since that is how they get all their knowledge and information they need to execute their task and serve their purpose.

Artificial Intelligence image recognition:

Using machine learning to analyze images that we feed it. It compares it to data and previous images that they have successfully identified to place it. The longer AI has been trained, the more accurate it is, just like humans. It can identify humans, objects, places, actions, and more, but might be inaccurate if they were not trained to recognize the thing you are showing it.

Google Gemini is a chatbot. It helps with advice, research, **image recognition**, and can come up with stories and images.

LogMeal is a platform that is meant to identify foods of all types. It is not meant to identify varieties of fruits.

Section Five: Scientific Question and Purpose

Can Artificial Intelligence (AI) be used to identify fruit, instead of using plastic PLU codes on stickers?

Motivation:

More than ever now, there are billions of tiny plastic pieces going into the ocean. This pollution harms animals, because they eat the plastics and get harmed by the chemicals. Plastic also lands on the ground, and since it takes hundreds of years to decompose, it will remain there and pollute the soil and environment.

We wanted to stop this, so we had to find a cost effective way that is efficient and fast but also had the same purpose as a PLU code. One day we were playing with a built-in app on our phone, Google Lens, another image recognition app. We had lots of fun taking pictures of random stuff and seeing what the results were. We then had an idea to use AI in our experiment, which is how this project got started.

Section Six: Hypothesis

We think that AI will be able to identify some common and obvious types of fruit, but not different varieties of the same fruit.

Section Seven: Experimental Design and Procedure

Experimental Design:
Materials:

- Baking pan: mimic grocery store check-out weight scanner
- White trifold: provide a plain background
- Phone holder + phone with camera: steady camera scanner
- Bright lights: well-lit background
- Plastic bags: fruit grocery bags at stores
- AI platform: the part where the scanner can identify fruit by looking at it.
- Fruit types and varieties

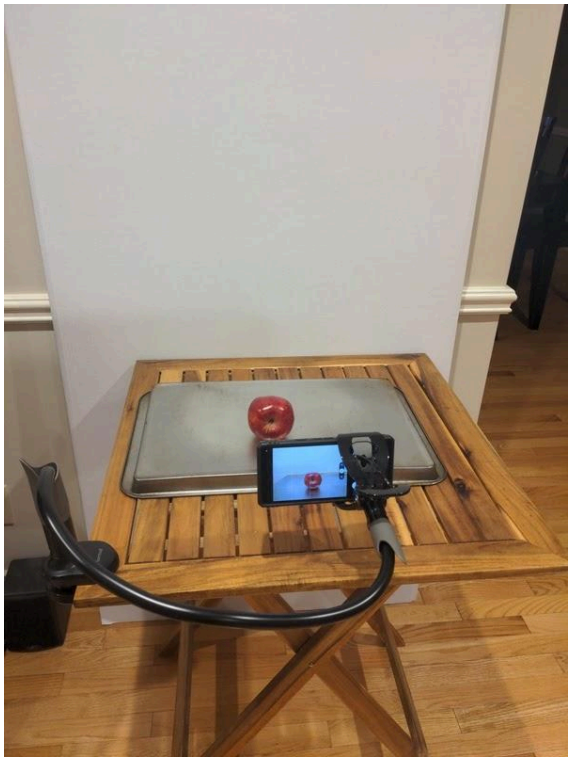
In order to have the results as accurate as possible, we have made our set-up as similar to a checkout machine, and its surroundings as possible. We wanted to have a good lighting source and a simple background, as well as a metal surface. We put the back of our old trifold, which would act as that white background. A metal baking pan would act as the metal weight scanner, and we tried to have the lighting not too dark. We used a phone to act as the camera scanner, with a stand so it stays in position for each photo. It mimics realistic grocery setting. A check-out scanner with scale, and fruit in plastic grocery bags.

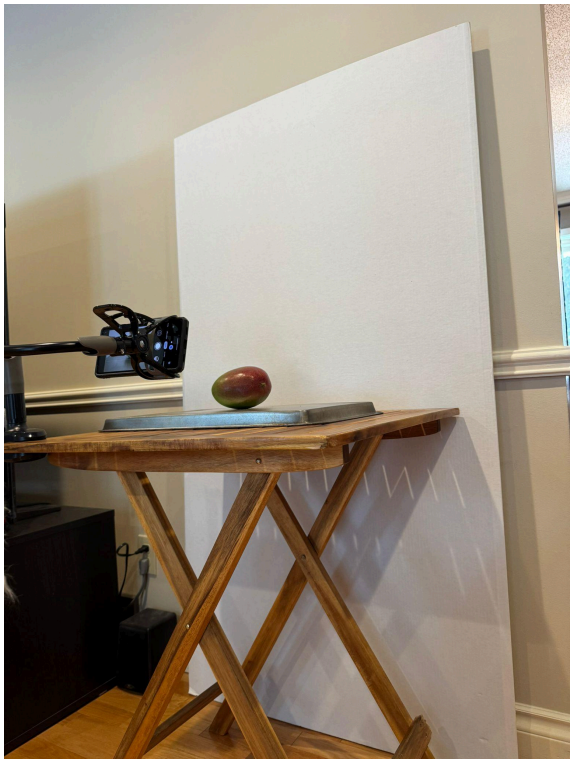
Why did we choose AI and not stick to the already invented options? These may sound like good ideas but there are some cons about all of them.

- Sticker Fruit Wash: The reason that we can't do this is because researchers think that it is more efficient to wash fruit with just normal soap and water, and it does the same, if not more. Also this is expensive.
- Compostable Stickers: They are expensive and Farmers do not want to switch from the less expensive option- plastic.
- Laser Imprinting: It works, but does not work on all fruits, because fruits such as oranges, would heal the burn in their skin.

Since technology is advancing with robots and AI, we feel that using AI to identify fruits in our experiment would fit into the AI dominance. It was something that we had readily available to us, and certain platforms were free to the public. AI is already in lots of places that you may not think of, including healthcare, transportation, education, and Google Maps, and does many things. For example, in healthcare, AI analyzes the patient's medical history, and tells whether or not the patient is healthy, and if there are any risks.

Our Set-up:





Variables:

Controlled variables:

- lighting
- table position
- baking pan position
- camera position,
- trifold position
- Artificial Intelligence platforms (Google Gemini, LogMeal)

Manipulated variables:

- V1- Fruit Type
- V2- Fruit Variety
- V3- Bag types (Clear bag vs Translucent bag vs No bag)
- V4- Angle
- V5- AI Softwares

Responding variables:

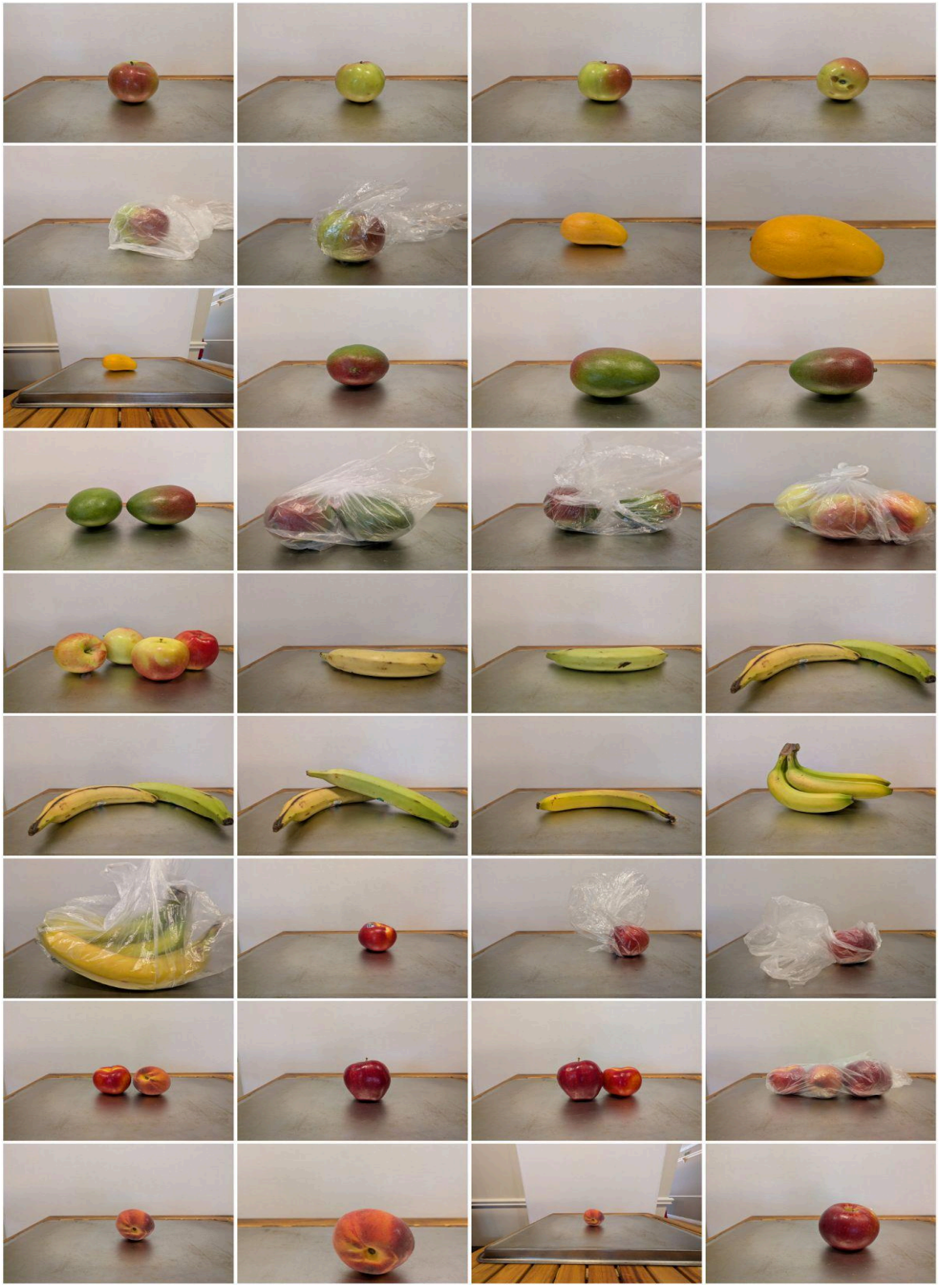
- the results from the AI softwares

Procedure:

1. Purchase and gather any fruits or materials you may need for this experiment.
2. Pick an area or room, which has sufficient light.
3. Get a sturdy, flat table that is large enough to place your baking pan on.
4. Place your table against the wall.
5. Get your trifold and place the backside between the table and wall. Make sure your trifold is large enough to cover the whole shot. This will be a good background and not distracting.
6. Place your metal baking pan in the center of the table, upside down, in order to create a flat surface.
7. Attach the phone holder on the left side of the table, near the edge.
8. Bend the phone holder, so it is pointing directly at the set-up, horizontally.
9. Place the phone in the holder and make sure it is secure and won't move around.
10. Get your plastic bags ready to use.
11. Get your first fruit and place it in the middle, and take a picture of whatever variables you want, making sure you keep the phone steady and in the same position for each shot. (bags, angle, type, etc.)
12. Keep the set-up the same, while changing out the fruits and variables.

13. Once you have all of your photo variables, input each individual picture file into Google Gemini and LogMeal, so that there will be two opinions about the picture for each set of pictures.
14. Gather all your information into a chart or table.

Section Eight: Observations



Our original data table:

Picture Numbers	Type of Fruit	# of Fruit	Angle	Type of Bag	Notes	Log Meal	Google Gemini
205537472	Ambrosia Apple	4	Upright	None		Apple	4 Honeycrisp Apples
205344647	Ambrosia Apple	4	Horizontal	T. Bag	Mix Colour	Apple	3 Honeycrisp or Braeburn Apples in Bag
203806335	Ambrosia Apple	4	Horizontal, upright	None	Mix Colour	Apple	4 Honeycrisp Apples
234104168	Ambrosia Apple	1	Upright	None	Yellow, red mix	Apple	Fuji/Gala Apple
234125483	Ambrosia Apple	1	Upright	None	Red side	Apple	Fuji/Gala Apple
234151202	Ambrosia Apple	1	Bottom	None		Apple	Fuji/Gala Apple
234224976	Ambrosia Apple	1	Top stem	None		Apple	Fuji/Gala Apple
210732447	Apples	5	Upright	None	All variations	4 Apples	ı, Red Delicious, Honeycrisp/Fuji, B
210804948	Apples	5	Upright	T. Bag	All variations	4 Apples	la, Golden Delicious/Honeycrisp, Gı
210609776	Cosmic Crisp	1	Upright	None		Apple	Red Delicious Apple
211522187	Cosmic Crisp	1	TopStem	None		Apple	Honeycrisp Apple
233907863	Cosmic Crisp	1	Upright	None		Apple	Honeycrisp Apple
233920767	Cosmic Crisp	1	Bottom	None	Bottom Stem	Apple	Red Delicious Apple
234337019	Cosmic Crisp	1	Top stem	None		Apple	Honeycrisp/Braeburn Apple
210851460	Granny Smith	1	Upright	None	Slight red spot	Apple	Granny Smith Apple
211527703	Granny Smith	1	Top Stem	None		Apple	Granny Smith Apple

234420922	Granny Smith	1	Top stem	None		Apple	Granny Smith Apple
234901659	Granny Smith	1	Upright	C. Bag		Pear, Apple	Granny Smith Apple
203806335	McIntosh Apple	1	Upright	None	Red side	Apple	Honeycrisp/Braeburn Apple
204016608	McIntosh Apple	1	Upright	None	Green side	Apple	Granny Smith Apple
204052600	McIntosh Apple	1	Upright	None	Mix Colour side	Apple	Honeycrisp Apple
204139424	McIntosh Apple	1	Bottom	None		Apple	Honeycrisp Apple
204541625	McIntosh Apple	1	Upright	T. Bag	Mix Colour side	Apple	Honeycrisp Apple covered by Bag
204614128	McIntosh Apple	1	Upright	C. Bag	Mix Colour side	Apple	Honeycrisp Apple in Plastic Wrap
234300179	McIntosh Apple	1	Top stem	None		Apple	Honeycrisp/Braeburn Apple
233801222	Red Delicious	1	Upright	None		Apple	Red Delicious Apple
233815415	Red Delicious	1	Bottom	None	Bottom Stem	Apple	Red Delicious Apple
234809539	Red Delicious	1	Horizontal	C. Bag		Strawberry	Red Delicious Apple
234444266	Red Delicious	1	Top stem	None		Apple	Red Delicious Apple
210248739	Red Delicious	1	Upright	None		Apple	Red Delicious Apple
204647456	Ataulfo Mango	1	Horizontal	None		Lemon, Mango	Ripe Mango
204736349	Ataulfo Mango	1	Horizontal	None		Mango	Atauflo Mango
204750412	Ataulfo Mango	1	Horizontal	None		Lemon	Mango
204918841	Red Mango	1	Stem	None	Red side	Mango, Pomegranate	Tommy Atkins Mango
205044118	Red Mango	1	Horizontal	None	Green	Mango	Tommy Atkins Mango

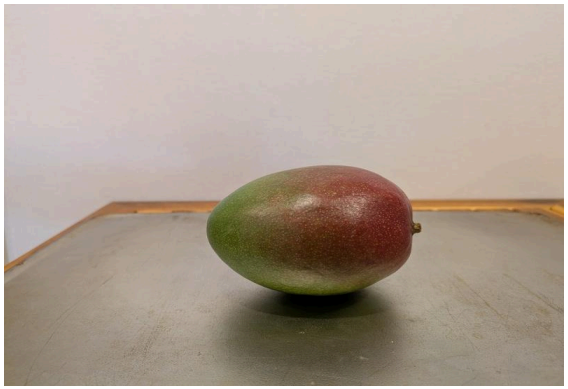
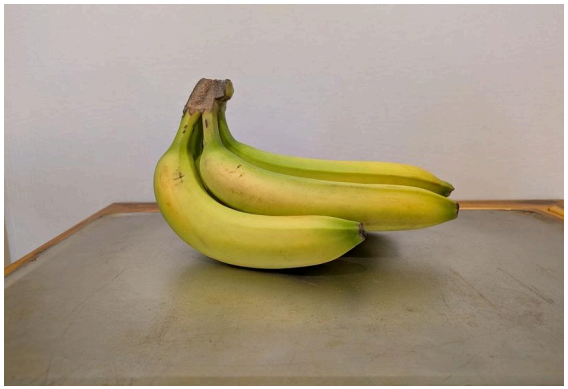
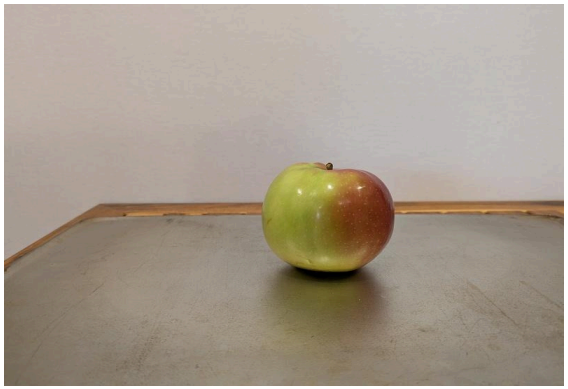
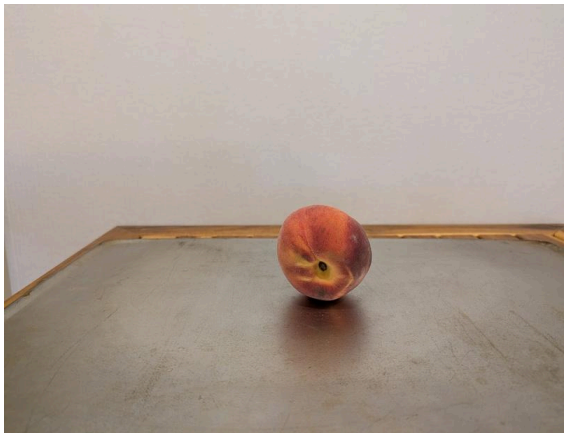
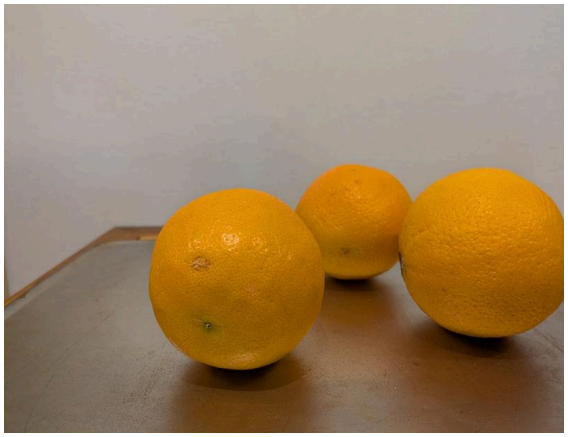
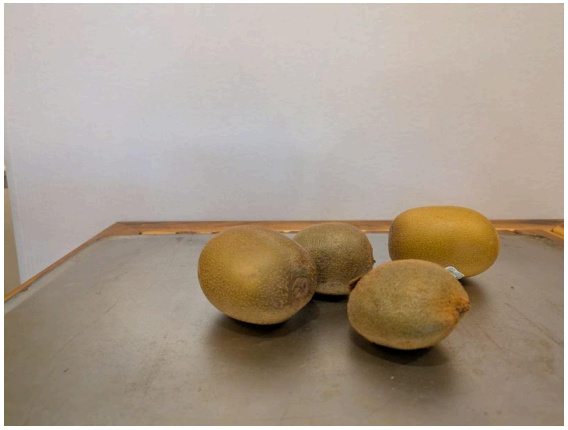
205108765	Red Mango	1	Horizontal	None	Mix Colour	Mango	Tommy Atkins Mango
205144944	Red Mango	2	Bottom, horizontal	None	1 green, 1 mixed	2 Mango	Tommy Atkins Mangoes
205223187	Red Mango	2	Horizontal	T. Bag	1 green, 1 red	Prickly pear, pear	Tommy Atkins Mangoes in Bag
205312013	Red Mango	2	Horizontal	C. Bag	1 mix, 1 red	Orange, Cucumber	Tommy Atkins Mangoes in Bag
210415046	Peach	1	Top Stem	None		Nectarine	Peach
210426397	Peach	1	Top Stem	None		Nectarine, Peach	Peach
210524219	Peach	1	Top Stem	None		Nectarine, Peach	Peach
211400294	Peach	1	Top Stem	None		Nectarine	Peach
210019790	Nectarine	1	Upright	None	With sticker	Apple	Nectarine
210039057	Nectarine	1	Upright	C. Bag		Apple, Biscuits	Red Apple in Bag
210108483	Nectarine	1	Upright	T. Bag		Apple, Tomato	Red Apple in Plastic Wrap
205834741	Banana	1	Horizontal	None	Ripe	Banana	Cavendish Banana
205917277	Banana	4	Horizontal	None	Bunch	Banana	Bunch of Cavendish Bananas
205941609	Banana	5	Horizontal	T. Bag	All	Banana	2 Cavendish Bananas in Bag
205644350	Green Plantain	1	Horizontal	None		Banana	Cavendish Banana
205701998	Plantain	2	Horizontal	None	Yellow, green	Banana	2 Plantains
205707652	Plantain	2	Stacked	None	Yellow, green	Banana	2 Plantains
205628420	Yellow Plantain	1	Horizontal	None		Banana	Banana
211742922	Golden Kiwi	4	Horizontal	T. Bag	Together	Pear, Tin Loaf, Apple	Hayward Kiwis in Bag

211834631	Golden Kiwi	5	Upright, Horizontal	C. Bag		Kiwi	Hayward Kiwis in Bag
212111765	Kiwi	4	Horizontal	None	2 Golden, 2 Regular	Kiwi	4 Hayward Kiwis
211948128	Regular Kiwi	2	Horizontal	T. Bag		lty Biscuits, Taai T	Hayward Kiwis in Bag
212034418	Regular Kiwi	2	Horizontal	C. Bag		Chocolates, Pandan cake	Hayward Kiwis in Bag
210935200	Clemintine Orange	6	Upright	Original bag	Stacked	Tangerine	Clementine Orange
211214634	Mandarin Orange	>10	Stem, Front	Mesh original bag	All in pile (more than you can count)	Tangerine	Approximately 15 Mandarin Oranges
211052559	Navel Orange	4	Upright	T. Bag	Stacked	Melon, Tangerine	2 Oranges in Bag
211130407	Navel Orange	3	Top Stem	None		Orange	3 Oranges
211236706	Ataulfo Mango, Green Plantain	2	Horizontal	None	Stem	Banana	Mango and Plantain
210213721	Nectarine, peach	2	Front, stem	None		2 Nectarines	Nectarine and Peach
210335098	Nectarine, peach, Red Delicious	3	Upright	T. Bag		Apple, Orange	3 Red Delicious or Gala Apples
210304940	Red Delicious Apple, Nectarine	2	Upright	None		Apple, Nectarine	Red Delicious and Honeycrisp Apples
211304688	Red Mango, Granny Smith	2	Upright	None	Horizontal, upright	2 Apples	Mango and Granny Smith Apple

Section Nine: Managed Data

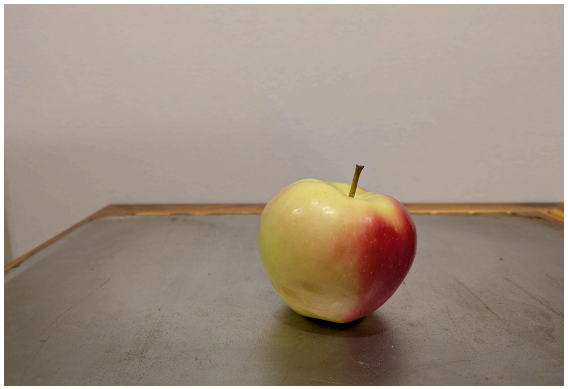
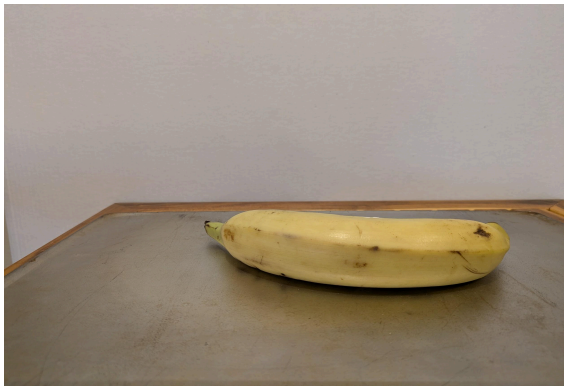
Variable 1- Different Kinds of Fruit:

Picture Numbers	Type of Fruit	# of Fruit	Notes	Log Meal	Google Gemini
205834741	Banana	1	Ripe	Banana	Cavendish Banana
212111765	Kiwi	4	2 Golden, 2 Regular	Kiwi	4 Hayward Kiwis
210019790	Nectarine	1	With sticker	Apple	Nectarine
210415046	Peach	1		Nectarine	Peach
210609776	Apple	1		Apple	Red Delicious Apple
205108765	Red Mango	1	Horizontal	Mango	Tommy Atkins Mango
211130407	Navel Orange	3	Top Stem	Orange	3 Oranges

Variable 2- Specific variety of Fruit:

Picture Numbers	Type of Fruit	# of Fruit	Notes	Log Meal	Google Gemini
234125483	Ambrosia Apple	1	Red side	Apple	Fuji/Gala Apple
210609776	Cosmic Crisp	1		Apple	Red Delicious Apple
210851460	Granny Smith	1	Slight red spot	Apple	Granny Smith Apple
203806335	McIntosh Apple	1	Red side	Apple	Honeycrisp/Braeburn Apple
233801222	Red Delicious	1		Apple	Red Delicious Apple
204736349	Ataulfo Mango	1		Mango	Atauflo Mango
205108765	Red Mango	1	Mix Colour	Mango	Tommy Atkins Mango
210935200	Clementine Orange	6	Stacked	Tangerine	Clementine Orange
211214634	Mandarin Orange	>10	All in pile (more than you can count)	Tangerine	Approximately 15 Mandarin Oranges
211130407	Navel Orange	3		Orange	3 Oranges
205644350	Green Plantain	1		Banana	Cavendish Banana
211834631	Golden Kiwi	5		Kiwi	Hayward Kiwis in Bag

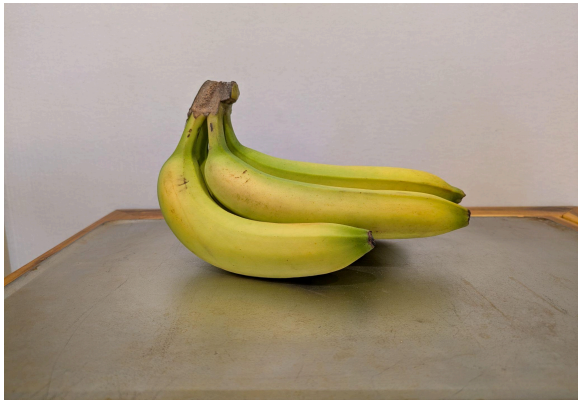




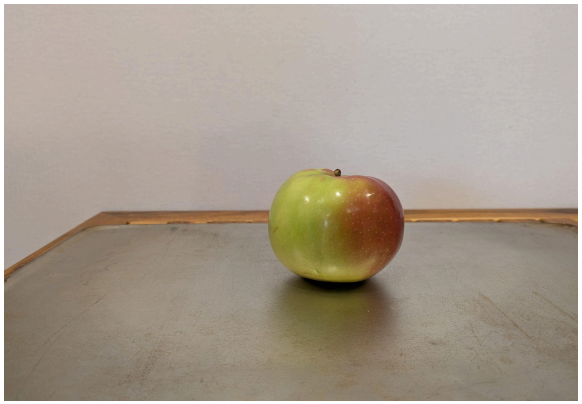

Variable 3- Clear bag vs Translucent bag vs No bag:

Picture Numbers	Type of Fruit	# of Fruit	Type of Bag	Notes	Log Meal	Google Gemini
205537472	Ambrosia Apple	4	None		Apple	4 Honeycrisp Apples
205344647	Ambrosia Apple	4	T. Bag	Mix Colour	Apple	3 Honeycrisp or Braeburn Apples in Bag
210851460	Granny Smith	1	None	Upright	Apple	Granny Smith Apple
234901659	Granny Smith	1	C. Bag		Pear, Apple	Granny Smith Apple
204541625	McIntosh Apple	1	T. Bag	Mix Colour side	Apple	Honeycrisp Apple covered by Bag
204052600	McIntosh Apple	1	None	Upright	Apple	Honeycrisp Apple
204614128	McIntosh Apple	1	C. Bag	Mix Colour side	Apple	Honeycrisp Apple in Plastic Wrap
234809539	Red Delicious	1	C. Bag		Strawberry	Red Delicious Apple
233801222	Red Delicious	1	None		Apple	Red Delicious Apple
205108765	Red Mango	1	None	Mix Colour	Mango	Tommy Atkins Mango
205223187	Red Mango	2	T. Bag	1 green, 1 red	Prickly pear, pear	Tommy Atkins Mangoes in Bag
205312013	Red Mango	2	C. Bag	1 mix, 1 red	Orange, Cucumber	Tommy Atkins Mangoes in Bag
210019790	Nectarine	1	None	With sticker	Apple	Nectarine
210039057	Nectarine	1	C. Bag		Apple, Biscuits	Red Apple in Bag
210108483	Nectarine	1	T. Bag		Apple, Tomato	Red Apple in Plastic Wrap
205917277	Banana	4	None		Banana	Bunch of Cavendish Bananas
205941609	Banana	5	T. Bag	All	Banana	2 Cavendish Bananas in Bag
211742922	Golden Kiwi	4	T. Bag	Together	Pear, Tin Loaf, Apple	Hayward Kiwis in Bag

211834631	Golden Kiwi	5	C. Bag		Kiwi	Hayward Kiwis in Bag
211948128	Regular Kiwi	2	T. Bag		Salty Biscuits, Taai Taa	Hayward Kiwis in Bag
212034418	Regular Kiwi	2	C. Bag		Chocolates, Pandan cake	Hayward Kiwis in Bag
210935200	Clementine Orange	6	Original bag	Stacked	Tangerine	Clementine Orange
211214634	Mandarin Orange	>10	Mesh original bag	All in pile (more than you can count)	Tangerine	Approximately 15 Mandarin Oranges
211052559	Navel Orange	4	T. Bag	Stacked	Melon, Tangerine	2 Oranges in Bag
211130407	Navel Orange	3	Top Stem	None	Orange	3 Oranges



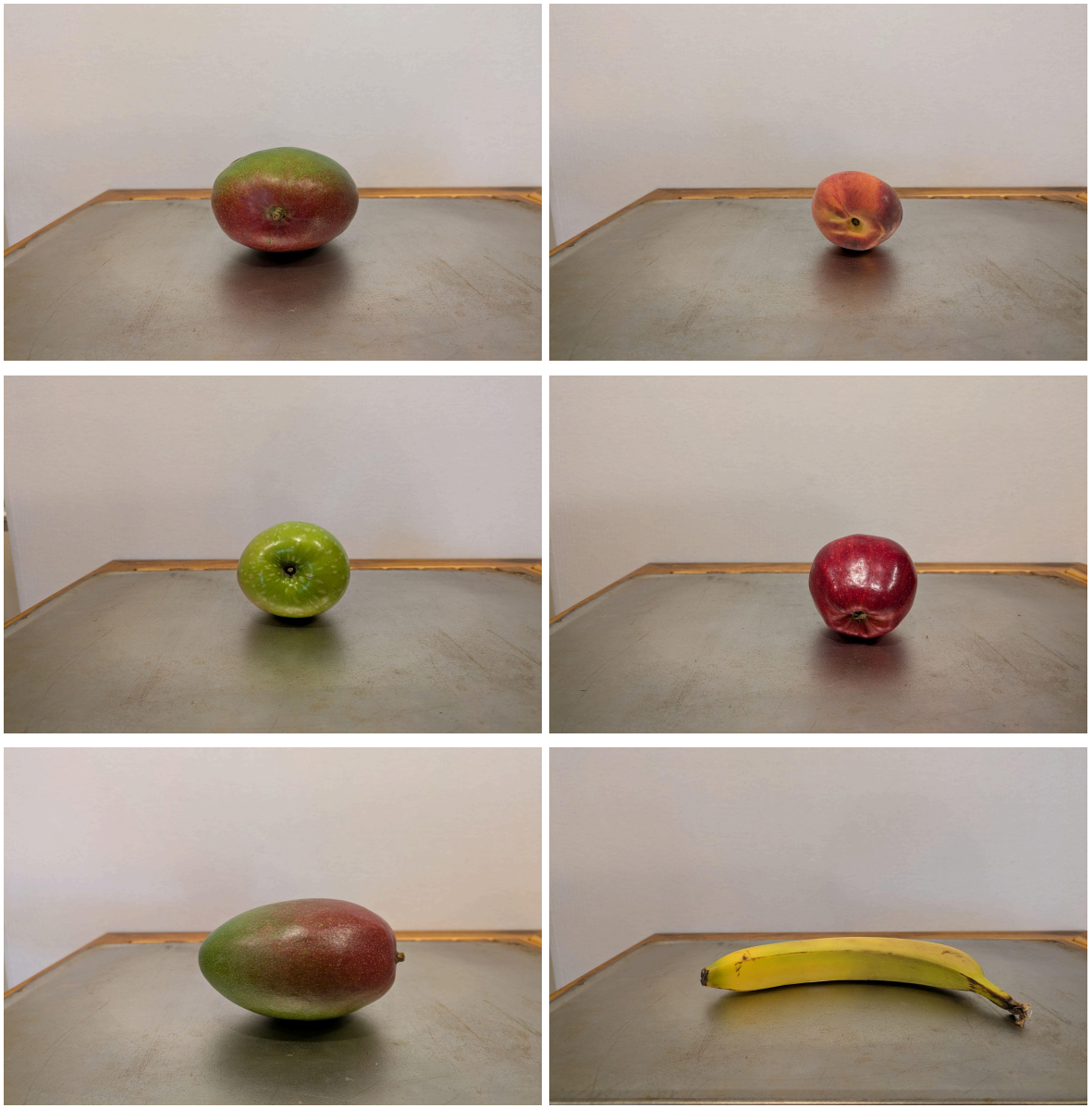





Variable 4- Angle and position:

Picture Numbers	Type of Fruit	# of Fruit	Angle	Notes	Log Meal	Google Gemini
205537472	Ambrosia Apple	4	None		Apple	
234151202	Ambrosia Apple	1	Bottom		Apple	Fuji/Gala Apple
234224976	Ambrosia Apple	1	Top stem		Apple	Fuji/Gala Apple
211522187	Cosmic Crisp	1	Top Stem		Apple	Honeycrisp Apple
233920767	Cosmic Crisp	1	Bottom	Bottom Stem	Apple	Red Delicious Apple
234337019	Cosmic Crisp	1	Top stem		Apple	Honeycrisp/Braeburn Apple
210851460	Granny Smith	1	Upright	Slight red spot	Apple	Granny Smith Apple
211527703	Granny Smith	1	Top Stem		Apple	Granny Smith Apple
234420922	Granny Smith	1	Top stem		Apple	Granny Smith Apple
203806335	McIntosh Apple	4	Horizontal, upright	Mix Colour	Apple	4 Honeycrisp Apples
204139424	McIntosh Apple	1	Bottom		Apple	Honeycrisp Apple
234300179	McIntosh Apple	1	Top stem		Apple	Honeycrisp/Braeburn Apple
233801222	Red Delicious	1	Upright		Apple	Red Delicious Apple
233815415	Red Delicious	1	Bottom	Bottom Stem	Apple	Red Delicious Apple
234444266	Red Delicious	1	Top stem		Apple	Red Delicious Apple
204918841	Red Mango	1	Stem	Red side	Mango, Pomegranat	Tommy Atkins Mango

					e	
205044118	Red Mango	1	Horizontal	Green	Mango	Tommy Atkins Mango
205144944	Red Mango	2	Bottom, horizontal	1 green, 1 mixed	2 Mango	Tommy Atkins Mangoes
210415046	Peach	1	Top Stem		Nectarine	Peach
210426397	Peach	1	Top Stem		Nectarine, Peach	Peach
210524219	Peach	1	Top Stem		Nectarine, Peach	Peach
211400294	Peach	1	Top Stem		Nectarine	Peach
205917277	Banana	4	Horizontal	Bunch	Banana	Bunch of Cavendish Bananas
205707652	Plantain	2	Stacked	Yellow, green	Banana	2 Plantains



Section Ten: Results and Conclusion

Results/Analysis:

Results for each variable:

Variable 1- Fruit Types:
Google Gemini successfully identified all the fruits correctly 7/7, though for the Navel orange, it only put “orange”, while LogMeal, only identified 5/7 correctly. LogMeal mixed up peaches with nectarines and we think that is because a peach and nectarine are similar, but a peach is fuzzier. We think that the pictures may not have been clear enough and the LogMeal could not see the fuzziness. LogMeal also could not identify a nectarine and responded by saying it was an apple. We think that because nectarines and apples are both fuzzy, LogMeal mixed them up, since you could not see how big they are in the picture unless put side by side. LogMeal was not very specific about the varieties of fruits.

Percentage of correct pictures: Gemini - 100% LogMeal - 71.43%
(% calculation: # of correct pictures / total pictures)

Variable 2- Fruit Variety:
Google Gemini mixed up some apples, with other varieties, except for Granny Smith, which we think because it has a distinct colour and shape. It also mixed up a plantain with a banana, since it may look like an unripe banana. Otherwise, it identified everything else, but it still said that a Navel orange is just an “orange”. Google Gemini got 8/12 correct. LogMeal mixed up the oranges, thinking that a clementine and mandarin orange are tangerines. We think that is because they have that similar small size and flatness. It also said that the plantain was a banana. We believe that it said that because LogMeal would think it looks like an unripe banana. LogMeal got 9/12. We think that with better training, Google Gemini could identify different varieties of apples.

Percentage of correct pictures: Gemini - 66.67% LogMeal - 75%
(% calculation: # of correct pictures / total pictures)

Variable 3- Clear bag vs Translucent bag vs No bag:
Google Gemini seems to not be affected by the bags, because its answers are the same vs different bags and no bags. It identified Ambrosia apples and McIntosh apples wrong, thinking they were Honeycrisp and Braeburn apples. However, we don’t think it was because of the bags, since it said the same thing to the same fruit without a bag. Google Gemini also thought a nectarine was a red apple in a bag, but without a bag, it said it was a nectarine. We think that the

bag might have blurred some key details in colours and patterns on the skin of the nectarine. Google Gemini got 19/26 correct. LogMeal seemed to be more affected by the bags and it thought a Granny smith was a pear and Red delicious was a strawberry. We think that the bag might have blurred some details. It also mixed up Tommy Atkins, Nectarines and kiwis, and we think because they were mostly in bags. LogMeal got 14/26 correct. Google Gemini could usually identify the fruits correctly in the clear bag, but not so much in the translucent bags. For LogMeal it seemed like it didn't really matter what type of bag it was; it mixed almost half of the fruit up.

Percentage of correct pictures: Gemini - 73.08% LogMeal - 53.85%
(% calculation: # of correct pictures / total pictures)

Variable 4- Angle and Position:
Google Gemini tried to identify the fruits, but it seems the angle of the fruits affected the results. It just got apples wrong. It was able to identify Granny Smith apples and Red Delicious apples, as well as peach, red mango, and bananas and plantains. We think that because of the colour and shape of the apples- how they are so similar- it made Google Gemini mix them up, but other fruits and Granny Smith and Red Delicious apples have a distinct colour and shape. It didn't matter what angle the fruit was at, it still mixed up the apples. Google Gemini got 16/25 correct. LogMeal, since it doesn't identify variety, just said that all angles and types of apples were apples. Since it doesn't identify variety, we couldn't tell if the angle affected it. The only ones it got truly wrong were the mangos (thinking it was a mango, then pomegranate), peaches (thinking they were nectarines), and the plantain (thinking it was a banana- though LogMeal has never identified it correctly). It doesn't seem like the angle affected LogMeal, as it still identified certain fruits. LogMeal got 19/25 correct.

Percentage of correct pictures: Gemini - 64% LogMeal - 76%
(% calculation: # of correct pictures / total pictures)

Variable 5- AI software:
Comparing Google Gemini and LogMeal, in short, Google Gemini is much better than LogMeal. Google Gemeni tries to identify the type and variety of fruit, while LogMeal just identifies the type of fruit- though that is what it was made for (it said on the website). Google Gemini generally identifies all the fruits correctly, and usually mixes up certain varieties of apples, such as Ambrosia, Cosmic Crisp, and McIntosh. It sometimes gets oranges wrong, as well as plantains, but can identify all the other things (besides apples). LogMeal can usually identify mangos right, and bananas, and in addition, can also identify that an "apple is an apple", though it only says "apple". It also mixes up oranges, peaches, plantains, kiwis. So taking all this into consideration, Google Gemini would probably work best if this was in real life.

Percentage of correct pictures: Gemini - 75.94% LogMeal - 69.07%
(% calculation: average # of correct pictures for each variable)

Conclusion:

Answering our hypothesis, which was “We think that AI will be able to identify some common and obvious types of fruit, but not different varieties of the same fruit”, our two AI softwares could identify fruit, but some different varieties and/or fruit types messed them up. Our data partially supports our hypothesis.

Our experiment was to see if AI can identify fruit types and varieties, but with variables that mimic a realistic grocery store. We took pictures of fruits, with these variables, and imputed each picture into each AI software. We chose these certain variables because we wanted this experiment to be as realistic as possible, so in the future, if AI was to be in a store, this information, that we have gathered, could help with future AI development.

Overall Google Gemini can identify most types and varieties of fruits, though it doesn’t usually identify Cosmic crisp apples, Ambrosia apples, and McIntosh. Sometimes it does not identify plantains, and sometimes it does.

LogMeal cannot identify varieties of apples, or any fruit- that is not what it was made for. But for other fruits it does a pretty good job of identifying, except for kiwis and peaches. Sometimes it can identify a kiwi, though not usually. Peaches, however, it cannot identify- it just says “nectarine”, maybe because they look similar.

As for the variables, Google Gemini was most affected by the bags, and the angle did affect it. LogMeal didn’t seem to really be affected by our variables. With some training and programming Gemini could be better at identifying fruits, and could even eventually be put in use in stores, helping with inventory checks and being more efficient. Overall Google Gemini has a percentage of 75.94% accuracy. LogMeal has a 69.07% accuracy. Though Google Gemini had a higher percentage, LogMeal isn’t far behind, and for some variables had more correct results than Google Gemini. (% calculation: average # of correct pictures for each variable)

We think that Google Gemini could be used in stores for inventory checks, making people's lives easier and more efficient, while also reducing the need for plastic fruit stickers that keep ending up in landfills. LogMeal could too, with more time and work into identifying varieties of fruits and not identifying other objects.

In the end, we think with programming and training, programmers could use this information to update the AI, and with time, there might be an AI programmed just for this purpose:

Recognizing fruits at the grocery checkout.

Section Eleven: Sources of Error

1. Due to money, we could not buy more fruits and varieties, which could have provided a larger dataset to perform the experiment and possibly provide more information
2. Unable to access certain AI platforms, or paid ones, which could have been better at identifying types and varieties of fruit
3. It was not possible to setup an environment at home that is exactly the same as a grocery store check-out scanner, and we cannot perform the experiment in an actual store
4. If we used a higher quality and better resolution camera than the one from a smartphone, the images might be better and the AI might have a higher chance of identifying fruits

Section Twelve: Applications, Improvements, and Future Questions

Application:
The results that we collect can be useful for identifying fruits with AI, and also Artificial Intelligence image recognition could be used in stores soon, and that would help with inventory check and just make people's lives easier, cheaper, and more efficient. This could also help improve image recognition- they could program it better. Also if this decides to be put in stores, there could be just one AI software that can identify produce, snacks, or anything, with the right programming.

Improvements:

1. We could have bought more fruit types and varieties.
2. We could have actually thoroughly tested each AI website and used which ones were best. This may have affected our results positively.
3. We should set-up our experiment to what it really is like, which may have affected our results.
4. We should get a better, higher resolution camera, which could take better pictures, which the AI might have an easier chance identifying the fruit.

Future Question(s):

- Could we have made a program to identify fruits that would work better than the ones we had?
- If we were to take this further, we would definitely try to maybe conduct more tests, this time with all the variables for every single fruit, combined with more AI softwares.
- We might even program our own AI
- We might also try combining multiple methods, such as having a tiny fruit sticker that the AI can map to a certain fruit.
- Could we train an AI software that would work?

Section Thirteen: Five Page Summary

Background Research:

The fruit consumption in Canada per year in 2022 is 5,000,000 average apples, which means, 33,000,000,000 stickers, that end up going into landfills and collecting.

Artificial Intelligence is a collection of technologies that allow computers to perform tasks that normally need human intelligence to be done, such as learning, reasoning, problem solving, and interacting with others. AI systems can learn from experience and improve their performance. Data is crucial in the programming and learning process of AI.

Artificial Intelligence image recognition:
Using machine learning to analyze images that we feed it. It compares it to data and previous images that they have successfully identified to place it. The longer AI has been trained, the more accurate it is, just like humans.

Scientific Question and Purpose:

Can Artificial Intelligence (AI) be used to identify fruit, instead of using plastic PLU codes on stickers?

We have always been interested in the planet and we would like it to remain healthy. When we learned that there were billions of plastic fruit stickers going into the environment and harming animals, we wanted to try to find a friendly way that could have the same purpose as a PLU code.

Our motivation behind using the AI was that because the world was advancing with technology, we should use technology to solve this problem, since it would fit in. It would also be easier to continue on with in the future that way.

Hypothesis:

We think that AI will be able to identify some common and obvious types of fruit, but not different varieties of the same fruit.

Experimental Design and Procedure:

Materials:

- Old Trifold (white, 2 metres)
- Small Table
- Metal Baking Pan that is large enough to hold fruit
- Phone Holder with stiff arm

- Lights (normal LED)
- Phone able to take clear pictures of the fruit
- Clear plastic bag
- Translucent plastic bag
- Fruits
- Access to an AI platform (we used a public and free one)

Variables:
Controlled variables:
- lighting
- table position
- baking pan position
- camera position,
- trifold position
- Artificial Intelligence platforms (Google Gemini, LogMeal)

Manipulated variables:
- V1: Fruit Type
- V2: fruit variety
- V3 Bag types (Clear bag vs Translucent bag vs No bag)
- V4 angle

Responding variables:
- the results from the AI softwares.

Procedure:
1. Place a baking pan in a well-lit room, with a plain background.
2. Set up your camera to take a steady picture of your fruit.
3. Take pictures of your fruit varying the following parameters:
    a. Fruit Types
    b. Fruit Varieties
    c. Clear bag vs translucent bag vs no bag
    d. Angle and position
4. Ask AI to classify fruit and record the results.
5. Log your information into an organized spreadsheet.

Results and Conclusions

Variable 1- Fruit Types:
Google Gemini successfully identified all the fruits correctly 7/7, though for the Navel orange, it only put “orange”, while LogMeal, only identified 5/7 correctly. LogMeal mixed up peaches

with nectarines and we think that is because a peach and nectarine are similar, but a peach is fuzzier. We think that the pictures may not have been clear enough and the LogMeal could not see the fuzziness. LogMeal also could not identify a nectarine and responded by saying it was an apple. We think that because nectarines and apples are both fuzzy, LogMeal mixed them up, since you could not see how big they are in the picture unless put side by side. LogMeal was not very specific about the varieties of fruits.

Percentage of correct pictures: Gemini - 100% LogMeal - 71.43%
(% calculation: # of correct pictures / total pictures)

Variable 2- Fruit Variety:
Google Gemini mixed up some apples, with other varieties, except for Granny Smith, which we think because it has a distinct colour and shape. It also mixed up a plantain with a banana, since it may look like an unripe banana. Otherwise, it identified everything else, but it still said that a Navel orange is just an "orange". Google Gemini got 8/12 correct. LogMeal mixed up the oranges, thinking that a clementine and mandarin orange are tangerines. We think that is because they have that similar small size and flatness. It also said that the plantain was a banana. We believe that it said that because LogMeal would think it looks like an unripe banana. LogMeal got 9/12. We think that with better training, Google Gemini could identify different varieties of apples.

Percentage of correct pictures: Gemini - 66.67% LogMeal - 75%
(% calculation: # of correct pictures / total pictures)

Variable 3- Clear bag vs Translucent bag vs No bag:
Google Gemini seems to not be affected by the bags, because its answers are the same vs different bags and no bags. It identified Ambrosia apples and McIntosh apples wrong, thinking they were Honeycrisp and Braeburn apples. However, we don't think it was because of the bags, since it said the same thing to the same fruit without a bag. Google Gemini also thought a nectarine was a red apple in a bag, but without a bag, it said it was a nectarine. We think that the bag might have blurred some key details in colours and patterns on the skin of the nectarine. Google Gemini got 19/26 correct. LogMeal seemed to be more affected by the bags and it thought a Granny smith was a pear and Red delicious was a strawberry. We think that the bag might have blurred some details. It also mixed up Tommy Atkins, Nectarines and kiwis, and we think because they were mostly in bags. LogMeal got 14/26 correct. Google Gemini could usually identify the fruits correctly in the clear bag, but not so much in the translucent bags. For LogMeal it seemed like it didn't really matter what type of bag it was; it mixed almost half of the fruit up.

Percentage of correct pictures: Gemini - 73.08% LogMeal - 53.85%

(% calculation: # of correct pictures / total pictures)

Variable 4- Angle and Position:
Google Gemini tried to identify the fruits, but it seems the angle of the fruits affected the results. It just got apples wrong. It was able to identify Granny Smith apples and Red Delicious apples, as well as peach, red mango, and bananas and plantains. We think that because of the colour and shape of the apples- how they are so similar- it made Google Gemini mix them up, but other fruits and Granny Smith and Red Delicious apples have a distinct colour and shape. It didn't matter what angle the fruit was at, it still mixed up the apples. Google Gemini got 16/25 correct. LogMeal, since it doesn't identify variety, just said that all angles and types of apples were apples. Since it doesn't identify variety, we couldn't tell if the angle affected it. The only ones it got truly wrong were the mangos (thinking it was a mango, then pomegranate), peaches (thinking they were nectarines), and the plantain (thinking it was a banana- though LogMeal has never identified it correctly). It doesn't seem like the angle affected LogMeal, as it still identified certain fruits. LogMeal got 19/25 correct.

Percentage of correct pictures: Gemini - 64% LogMeal - 76%
(% calculation: # of correct pictures / total pictures)

Variable 5- AI software:
Comparing Google Gemini and LogMeal, in short, Google Gemini is much better than LogMeal. Google Gemeni tries to identify the type and variety of fruit, while LogMeal just identifies the type of fruit- though that is what it was made for (it said on the website). Google Gemini generally identifies all the fruits correctly, and usually mixes up certain varieties of apples, such as Ambrosia, Cosmic Crisp, and McIntosh. It sometimes gets oranges wrong, as well as plantains, but can identify all the other things (besides apples). LogMeal can usually identify mangos right, and bananas, and in addition, can also identify that an "apple is an apple", though it only says "apple". It also mixes up oranges, peaches, plantains, kiwis. So taking all this into consideration, Google Gemini would probably work best if this was in real life.

Percentage of correct pictures: Gemini - 75.94% LogMeal - 69.07%
(% calculation: average # of correct pictures for each variable)

Conclusion:
Answering our hypothesis, our two AI softwares could identify fruit, but some different varieties and/or fruit types messed them up. Our data partially supports our hypothesis.

As for the variables, Google Gemini was most affected by the bags, but the angle did not affect it. LogMeal didn't seem to really be affected by our variables. Overall Google Gemini has a

percentage of 75.94% accuracy. LogMeal has a 69.07% accuracy. (% calculation: average # of correct pictures for each variable)

In the end, we think with programming and training, programmers could use this information to update the AI, and with time, there might be an AI programmed just for this purpose: Recognizing fruits at the grocery checkout.

Sources of Error

1. Due to money, we could not buy more fruits and varieties, which could have provided a larger dataset to perform the experiment and possibly provide more information
2. Unable to access certain AI platforms, or paid ones, which could have been better at identifying types and varieties of fruit
3. It was not possible to setup an environment at home that is exactly the same as a grocery store check-out scanner, and we cannot perform the experiment in an actual store
4. If we used a higher quality and better resolution camera than the one from a smartphone, the images might be better and the AI might have a higher chance of identifying fruits

Applications, Improvements, and Future Questions

Application:
The results that we collect can be useful for identifying fruits with AI, and also Artificial Intelligence image recognition could be used in stores soon, and that would help with inventory check and just make people's lives easier, cheaper, and more efficient.

Improvements:
We think that we could have thought and started this project sooner, which would increase our time, and we would not feel as rushed. We think that we could have started thinking about our topic in the summer, leaving us more time to work on the project, which we will take into mind for next time. Learning from our past mistakes last year, we filled out our hypothesis sooner, before our actual project, which we had done in the past.

Future Question(s):
Could we have made a program to identify fruits that would work better than the ones we had? If we were to take this further, we would definitely try to maybe conduct more tests, and maybe program our own AI. We might also try having a tiny fruit sticker that the AI can map to a fruit.

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Section Fourteen: Glossary

Adhesive: A substance that is sticky and able to stick to things. (ex. Glue, tape).

ASTM D6400 Compliant: A material similar to plastic that is compostable.

Biodegradable: A material that can return to nature (can also leave behind some metal residue). Biodegradable materials are **not** compostable materials.

Compostable: A material that breaks down and creates something called **humus**, which is rich in nutrients and helps plants grow. Compostable materials **are** biodegradable.

Imprinting: Stamping an outline or mark on the surface of a material.

Microplastics: Extremely small pieces of plastic that animals can ingest, making them very ill.

PLU Code: Four or five digit numbers used to identify fruits and vegetables, to make check inventory more faster and accurate.

Residue: A substance or something that remains after the main part has been taken or removed. (ex. Tape after sticking it to a window for a long time).

Starch: A carbohydrate storage, usually found in many plants and vegetables.

Trophic: Related to feeding and nutrition.

Trommel: A cylindrical screen that rotates used to wash and sort pieces of ore.

Vinyl: A man made resin that consists of polyvinyl chloride- a polymer.