UBC Social Ecological Economic Development Studies (SEEDS) Student Report

An Investigation into Sustainable Materials for Reusable Cutlery

A Triple Bottom Line Assessment

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Abstract

It is important to look at many different aspects when improving sustainability in the world. Cutlery is one main concern for use in the SUB and many buildings across UBC. Plastic cutlery has been used for a long time due to its low economic costs, but it also generates a lot of waste to landfills. The purpose of this report is to find material that is suitable to replace the plastic cutlery. It will focus on 3 reusable materials for replacing plastic cutlery used in UBC. They are bamboo, stainless steel, and plant starch. Each material is covered in-depth from research through several articles and sources.

The three materials are compared by using triple-bottom line assessment. It was found that stainless steel is very durable, but it came with a high price. It also damages the local environment due to the waste it generates at the end of its life cycle. Plant starch is reusable and it is quite cheap; however, it is not as durable compared to bamboo and stainless steel. Furthermore, its plastic-like appearance may cause some concerns from consumers who would question the reusability. Over all, bamboo is the most suitable material because it's environmentally friendly, economically practical, and socially acceptable. Bamboo is a type of grass, so it does not need to be reseeded after its initial planting. Bamboo also produces 40% more oxygen than trees, which reduce the CO2 in the air. Bamboo cutlery is reusable and completely biodegradable.

Glossary

Austenite - also known as gamma phase iron, is a metallic non-magnetic allotrope of iron or a solid solution of iron, with an alloying element

Biodegradable - a substance capable of being decomposted by living organisms

Carmelize - Sugar is heated to high temperatures, causing them to turn brown

Chromium - a lustrous, hard, brittle, metallic element used in alloy steels for hardness and corrosion resistance, as in stainless steel

Chromium oxide - a bright-green crystalline powder, Cr_2O_3 , insoluble in water: used in metallurgy and as the pigment chrome green

Compostable - After a product breaks down, it releases valuable nutrients into soil which help the growth of trees and plants

Ferrite - also known as alpha iron (α-Fe), is a material science term for iron, or a solid solution with iron as the main constituent, with a body centered cubic crystal structure

Gallon pot - Unit of measurement for addressing the size of a pot used to grow plants. (ie. 5 gallon pot measures 12"x20" and ~75 lbs)

Harry Brearley - is usually credited with the invention of "rustless steel" (later to be called "stainless steel") in the anglophone world

Martensitic - a metastable microconstituent of any of various forms of carbon steel, produced by undercooling sufficiently below the normal transformation temperature, especially a hard, brittle product of the decomposition of austenite, produced in this way

Mineral Oil - a distillation product of petroleum, typically used as a lubricant, moisturizer, or laxative

Polyactic Acid – biodegradable polyester derived from plant starch such as corn, potato or tapioca

Precipitation hardening - also called age hardening, a heat treatment technique used to increase the yield strength of malleable materials, including most structural alloys of aluminum, magnesium, nickel and titanium, and some stainless steels

RePEaT - utensil set made out of recycled PET (polyethylene) plastic, also known as RPET

List of Abbreviations

APSC - Applied Science

GHG - Greenhouse Gas

PLA - Polylactic Acid

PET – Polyethylene Plastic

SEEDS - Social, Ecological, Economical, Development Studies

SUB - Student Union Building

CO2 - Carbon Dioxide

1.0 Introduction

Global climate change and greenhouse gas emissions have been very important topics in recent years. An increasing amount of countries, organizations, and companies have involved themselves in projects which help reduce waste disposal, energy consumption and carbon emission. In order to create a more sustainable campus, UBC has provided many opportunities which allow its students to participate in sustainability projects.

One of the sustainability projects offered by the UBC SEEDS program is to help reduce waste by selling green products in vending machine located at the student union building (SUB). Food and beverage outlets at the SUB are using plastic cutlery, which is made from petroleum-based chemicals. It is not biodegradable and causes toxic waste in landfills. The purpose of this report is to provide detailed information of reusable cutlery that is sustainable economically, environmentally, and socially. This report will cover plant starch, stainless steel, and bamboo through the triple bottom line assessment. Our recommendation is made based on the analysis of economical, social and environmental impacts of the three materials and which material provides the most benefits. This report discusses the economical, social and environmental impacts of each material; compares the benefits and weaknesses of three materials and recommends the material to be used for waste-reducing vending machine.

2.0 Plant Starch Cutlery

Plant starch cutlery is made from plant starch such as potato or corn. Potato based cutlery, also called spudware, is made from 80% potato starch and 20% soy oil. Corn based cutlery is commonly called PLA cutlery. It is made from 70% corn starch and 30% talc (World Centric). These materials are chosen for consideration for their sustainability, biodegradability, compost ability and cost effectiveness. Moreover, less energy consumed during production means less carbon emission to the atmosphere which helps reduce negative impact to our environment.

2.1.1 Economical

Since US is the world's largest corn producer, PLA cutlery has an abundant amount of renewable resources. PLA cutlery uses yellow dent field corn, which only consumes very little of available US corn crop.

Many companies sell PLA cutlery with the price comparable to the price of plastic ones. World Centric is one of them. The price can be less than 10 cents for a single fork or spoon. It varies from 5 cents to 20 cents depends on the material it is made from and quantity purchased. World Centric has done life cycle assessment and base on the result, PLA products "need less manufacturing energy and water and generate less waste." In addition, there is no special maintenance or handling costs for dealing with the products.

2.1.2 Environmental Impact

The starch utensils are mostly made in China, and some are manufactured within the United States. There are a few distributers in Canada who provide different plant starch tableware and packages. World Centric's factories in China provide their workers fair living

wages and benefits required by the government. No underage worker is employed.

It is a sustainable production because potato or corns are annually renewable resources. They can grow very quickly. It takes only a few months for potato to grow from seeds to harvest. U.S. has long history of growing corns and there are plenty of field corn resources in U.S.

The plant starch utensil lasts for months. A PhD student from UCLA actually did an experiment on spudware (Levesque, 2007). He posted his comments after trying a few months and comments, "the spoons are great. I have been using a few of them for months on a weekly basis. The tines of the forks tend to get twisted up." Therefore, students can use it for at least one semester.

Utensil made from plant starch looks identical to its plastic alternative. However, the products are environmentally friendly because they are biodegradable and compostable.
For example, it takes 180 days or longer for PLA cutlery to biodegrade and it can be composted at home. They won't leave a trace of an aftertaste. A graduate student from UC Davis has tested if spudware is biodegradable. He put one spud spoon in a jar of water and found it sprout some mold. He posted the test result on his blog: "the mold seems to be working its way into the blade of the spoon, which is starting to puff up with water. I guess they do biodegrade after all."

2.1.2.1 Energy consumption of production

The technology the manufacturers of World Centric are using is trying to reduce energy consumption and carbon emission. According to World Centric, the cutlery made from PLA has the same manufacturing process as the one made from plastic. The process includes injection molding and thermal formed. Unlike plastics, which is petroleum based chemicals; whereas PLA is corn based non toxic material.

World Centric derived energy needed to produce PLA products and claimed that the energy to produce two PLA forks is the same as the energy to produce one plastic fork, which means half of energy consumption is reduced.

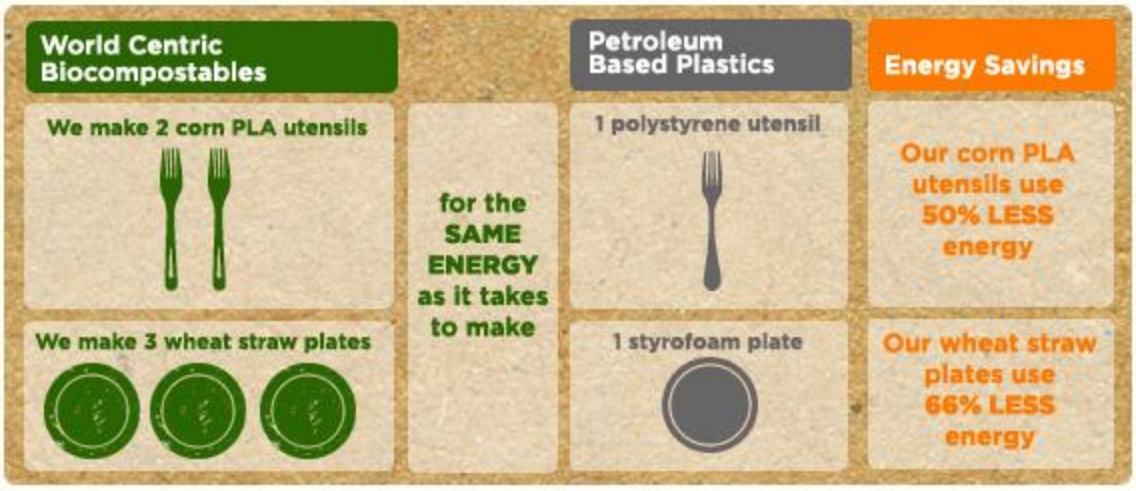

Figure 1 Energy saving for World Centric corn PLA utensils

2.1.2.2 Carbon Emission

World Centric has strived to offset carbon emissions from production to transportation. For example, a combination of wind and solar renewable energy system has been installed in their office. They also reimburse public transportation cost for their stuff. In addition, cooperated with other organization, they planned to plant 176,824 trees to offset carbon emission.

Figure 2 World Centric carbon footprint

2.3 Social Impact

2.3.1 Acceptance of reusable utensil

It is said that UCLA uses these at some of its campus eateries. A website shows the pools of 3052 people voting for "do you carry around reusable cutlery"? The result shows people's attitudes towards bringing their own reusable cutlery. Around 66% of people voted not carrying around reusable cutlery. However, from the comments they made, it seems they treated reusable cutlery as disposable cutlery. Most people have the sense that disposable utensils harm the environment and they either eliminate using them, eat food that fingers can handle, or keep one in their drawers or lockers to reuse (Care2, 2011).

According to World Centric, PLA utensil can resist heat up to 120 degree Fahrenheit. It is freezer safe; however, it is not microwavable. PLA can be easily cleaned and stored. PLA is non-toxic and harmless to human body; therefore, even if a piece of PLA product is accidentally swallowed, it will not cause any danger to human body.

2.3.2 Increase green awareness

A $15 "I'm not a plastic bag" designed by Anya Hindmarch quickly sold out in London in hours (Andrews, 2007). People love to go green if they can find a perfect product to fit their needs. If we want to sell green cutlery, we might think of the package and make it more attractive to people, meanwhile increase people's awareness of green products. For example, if the cutlery is made of corn starch, a little cartoon or picture can be printed on the handles of forks or spoons; or, a slogan such as: I'm not plastic but corn can also be used.

3.0 Stainless steel cutlery

3.1 Introduction

Stainless steel cutlery is almost environmentally friendly, and economically feasible, and socially acceptable. Harry Brearley invented stainless steels in Sheffield England in the 1912 when he was looking for corrosion-resistance alloy for gun barrels.

Figure 3 Stainless Steel Cutlery

Stainless steel is unique material compare to other iron alloy, and steel. It comes from a group of iron-base alloys, which don't rust in salty water, and are resistant to concentrated acids. They can also hold up to 1100 C of heat. Even in severe industrial environments it could last for several years. Unlike other unprotected carbon steel that rusts easily, stainless steel contains sufficient chromium to form a passive film of chromium oxide that can prevent surface corrosion, and block further corrosion. Because of its unique properties, stainless steel is also called corrosion-resistant steel**.** The ingredients for the first stainless steel are 9-16% chromium and less than 0.7% carbon. After years of experiment, scientists found 6 basic compositions of stainless steel: martensitic, martensitic-austenitic, ferritic, ferritic-austenitic, austenitic, and precipitaion hardening steels. The main elements for these compositions are carbon, chromium, nickel, molybdenum, and others. Different composition has different mixes of elements and serves different jobs for us.

Stainless steel is wildly being use more closely to our lives than other steels, for example it's used in households, restaurants, hospitals, gas industries, chemical process

industries, and food industries.

PRODUCT FORMS		APPLICATION CATEGORIES		
Cold rolled sheet	60 %	**Consumer items**		26 %
Bar and wire	20 %	Washing machines and dishwashers	8 %	
Hot rolled plate	10 %	Pans, cutlery, etc.	9 %	
Tube	6 %	Sinks and kitchen equipment	4 %	
Castings and other	4 %	Other	5 %	
		Industrial equipment		74 %
		Food industry and breweries	25 %	
		Chemical, oil and gas industry	20 %	
		Transport	8 %	
		Energy production	7 %	
		Pulp and paper, textile industry	6 %	
		Building and general construction	5 %	
		Other	5 %	

Figure 4 Manufacturing Costs

3.2 Environmental Impacts

Stainless steel was originally created to replace for carbon steel cutleries. Stainless steel cutlery is recyclable, save resources, and save energy. Stainless steel is 100% recyclable, about 80%-90% of stainless steels are going back to the factory waiting to be recycled, and only little in waste.

Figure 5 Steel Waste

Most of the stainless steel products we purchase contain about 60% of recycled stainless steel. Stainless steel contains valuable elements as nickel, chromium, and molybdenum. Because stainless steel is recyclable, we could mine less of these valuable materials out of the

ground. Every time we produce new product we could put in less raw materials, then mix with recycled stainless steel. In this way, we don't damage the local environment too much, and also saving energy for the locals by recycling. So when the stainless steel cutlery becomes a waste, we could just put it into the recycle bin, and let it come from other products, so nothing gets wasted. They are companies that purchase scarp stainless steel materials from household, so if people want, they could even make a few bucks from recycle the stainless steel cutlery.

3.3 Economic Impacts

Stainless steel cutlery is feasible for most of the people. Even most steel is recyclable, but the price of stainless steel cutlery is still expensive compare to others. One piece of cutlery is average 3-6 dollars, unlike plastic cutlery, which could go down to a few cents. However, if the consumers could maintain the stainless steel cutlery well, they could enjoy this cutlery for many years without purchasing another set. So in a short term, stainless steel cutlery is expensive, but in a long run, it could break even or even cheaper than plastic cutlery.

3.4 Social Impact

Stainless steel cutlery promotes sustainability to our daily lives. Of course, it's expensive to purchase, but it's also causes people to think about saving the materials. Making people more aware that it is expensive because these materials are being mined out of earth and they are very valuable. Unlike plastic cutlery, only cost a few cents, people generally don't care about where it comes from or going anywhere. And someday, if they don't want use steel cutleries anymore, they could return it to a recycle place, and help to save the environment and energy. Even stainless steel cutlery generates awareness of sustainability, but for students, stainless steel cutlery has a few disadvantages. First, it's expensive, if students could get something in a few cents, or even for free. They will not spend a few dollars to purchase these

cutleries. Second, it is heavy and large to carry. As many students carry laptop and textbooks in their backpack, carry a set of steel cutlery could only make matter worse. Stainless steel cutlery also attacks attentions from thieves, so security is another issue school has to address.

4.0 Bamboo

In recent times, bamboo has become a very popular substitute over wood for design various products. In particular, bamboo flooring has become an effective replacement for wooden flooring as bamboo can be harvested much faster than wood, while providing similar levels of durability. Bamboo also tends to last longer than wood products as they are less prone to splintering and splitting that wood suffers from through prolonged use.

There are many different species of bamboo, some of which are less durable and suitable for manufacturing. Therefore it is imperative to do proper research before buying a certain bamboo product. Different species of bamboo have varying levels of stability. In additional, some bamboo varieties tend to shrink and grow depending on the climate and temperature. All of these considerations must be taken when deciding to purchase any bamboo products.

Through the success of using bamboo for developing houses, manufacturing companies have expanded their range of work to other products including bamboo utensils. Our report will focus on RePEaT Bamboo Utensils which is being offered by Lavish & Lime. They offer any combination of forks, spoons, and knives made completely by bamboo. As mentioned before, our report will conduct a triple bottom line analysis of bamboo utensils to determine whether they are viable and sustainable for use for the new UBC Green Vending Machine which will be located in the SUB and potentially other buildings.

4.1 Economical Impacts

The cost of bamboo utensils tends to be similar to wooden products. The manufacturing process of bamboo involves the harvesting of bamboo, followed by a heating and drying process to extract any sugar inside the bamboo. Finally, a mineral oil coating is applied to extend the life cycle of the cutlery. Each step of the manufacturing process will be analyzed to

determine the cost of the total process.

4.1.1 Manufacturing Process

The first step is to harvest the bamboo. Since bamboo is a type of grass, it does not need to be replanted after the harvesting of resources. As such, there is only an initial cost for clear-cutting an area to reserve specifically for the planting of bamboo. Harvesting the bamboo itself can be quite a dangerous process, as they tend to grow up to several hundred feet in height. As such, proper training will be required before being able to cut down these trees. Initially, the first bamboo stalk requires frequent watering. Roughly twice a week during mild weather, a bamboo plant under 5 gallon pots requires about ½ gallon of water. Bamboo plants over 5 gallon pots requires 1 gallon of water twice a week. After the first 3-5 years, extensive watering is no longer necessary for any future bamboo plants; however a moderate amount is still necessary to ensure the bamboo grows well.

Figure 6 Harvested Bamboo

Figure 7Steam Machine

Next, the harvested bamboo must be processed at a factory to extract the sugar that is inside. To do this, typically the bamboo undergoes a heating process to become “caramelized”, which causes the visual browning of the bamboo. There are two cost factors to consider for this process. The first is the steam machine required to generate heat, which costs roughly $100 every week to operate. It requires a high amount of energy to generate high temperature steam. As such, a relatively high

cost is also required. Secondly, the cost to reshape and polish the bamboo requires the operation of heavy machinery as well. Overall, each individual piece of bamboo cutlery can cost roughly $0.10.

4.1.2 World Providers

Although bamboo has the possibility for growing anywhere around the world, it is commonly harvested and manufactured in China and East Asia due to its particular bamboo species being very durable and that China already has multiple established sites for growing bamboo. As such, transportation methods must be considered carrying bamboo over the Pacific Ocean. Therefore, there must be consideration for the amount of fuel required to carry several tons of bamboo. The density of bamboo is roughly 400 kilograms per cubic meter. It is lighter than most types of wood, therefore cheaper for transportation as well.

At Lavish & Lime, they offer a combined 4-piece set including a fork, spoon, knife, and chopsticks packaged for roughly $12 per bundle. Each piece could be sold individually in the vending machine for roughly $3 a piece, or higher if there is a desire for profit. It is also possible to forgo the purchase of the leather packaging for the set to help save some costs.

4.2 Environmental Impacts

One of the main reasons for choosing bamboo products is for their high environmental benefits. Bamboo is a highly regenerative product that offers multiple benefits outside of the actual product being provided. It shares many benefits similar to wood, but also provides other benefits to help benefit the environment.

Bamboo is a natural product, and it is a type of grass. As mentioned before, grass grows on its own without much need for fertilizers or pesticides. It does require a moderate amount of water; however, most of the water consumed is during the early phase of the bamboo's growth. Once the soil has matured over 3-5 years, bamboo requires less water, which variation

depending on the amount of sunlight it receives per day.

Bamboo is also completely biodegradable, as it an organic material which can breakdown into the earth given enough time. There is a concern about the mineral oil which would be applied to the bamboo cutlery. There is a general consensus that mineral oil is not very biodegradable. It is reported that roughly only 15% of mineral oil can be broken down. (Subtech) This could be a concern when promoting the environmental benefits of bamboo cutlery. Instead, vegetable lubricants could be applied instead; however, they have less temperature stability than mineral oil, so washing with hot water should be avoided.

Similar to other trees, bamboo also releases oxygen into the air. On average, bamboo releases 40% more oxygen than similar sized trees. Not only is this beneficial for people, oxygen benefits the growth of various other plants as well. This will also help reduce the amount of GHG emissions in the atmosphere. In addition, bamboo can be harvested 10 times earlier than wood. This helps to increase resource output levels, but bamboo must be harvested in moderation, as it is the main food that pandas eat. Pandas are currently an endangered species and it is important to help preserve their lives. Since cutlery uses a small amount of bamboo per item, harvesting levels should be fairly moderate as long as students continue to reuse their utensils.

4.3 Social Impacts

Bamboo would be ideal to use for utensils because of its low density. Compared to metal cutlery, bamboo would be lighter and easier to carry. This would be beneficial for students who are always travelling across campus. Despite cutlery being very lightweight to begin with, people have expressed their preference for lighter utensils, as it is also easier to wield while eating.

Similar to wood, bamboo faces some issues after prolonged use. Typically wood and bamboo start to split and have splinters when used repeatedly as they tend to become warn

down and brittle. To relieve this problem, the RePEaT bamboo utensils have been coated with mineral oil to ensure that the cutlery remain splinter-free; however, the mineral oil coating is not permanent, and additional coating must be applied after approximately a year of use. This may prove to be an inconvenience for users, as they may prefer to use metal cutlery that does not have such issues.

Furthermore, bamboo utensils must be hand-washed and wiped dry. Through our conversation with an employee from Lavish & Lime, he mentioned that the use of dishwashers should be avoided due to the high heat from the steam used to clean the dishes. Microwaving them is also not recommended for similar reasons. This high maintenance for cutlery could prove to be a deterrent for some people, but articles have reported that people are still very interested in purchasing bamboo cutlery as there are many advantages (Bamboo Skewers).

5.0 Comparisons

Below is a chart to compare three different materials based on Triple-bottom-line assessment.

	Bamboo	**Plant starch**	**Stainless steel**
Economical Impact			
Price range	Roughly $0.10 for individual piece of bamboo cutlery	US$0.05 ~ 0.20, depends on the materials used and size of orders	around $3-10 for each cutlery
Local availability	No local providers	There is local retailers or contributors	Factory operations in Waterloo
Environmental Impact			
Manufacturing Process	Includes harvesting of bamboo, heating and drying to extract any sugar inside bamboo and finally mineral oil coasting is applied.	Includes injection molding and thermal formed	Includes mining raw materials from ground
Resources used	Bamboo is a type of grass, thus it does not need to be replanted to reharvest; bamboo can be harvested every 2-3 years	Potato or corn starch is annually renewable resources.	Metals
Working conditions	bamboo harvesting typically occurs during fall/winter; factory work is fairly safe with no dangers	The workers are paid with fair living wages in accordance with living standards in China. The factory also provides housing, regular meals, normal work hours etc for it workers	Fair labor, relativity safe, and healthy
Sustainability	Bamboo is renewable resources and bamboo cutlery is biodegradable and compostable. There is no waste product produced and no negative impact to local environment	Potato or corn starch is annually renewable resources. The cutlery made from plant starch is biodegradable and compostable. There is no waste product produced and no negative impact to local environment	Stainless steel is recyclable. However, mining of raw materials may cause acid mine drainage which can pollute environment. Also it is heavy to transport which can cause more GHG emission

Social Impact			
Acceptance	It looks similar to wood. Many vendors already sell bamboo; it is an established market	It looks similar to plastic. Many organizations already put them into use	Already existed in markets for long time
Affordability	Affordable	Price is competitive to plastic cutlery.	Price is relative high compared to other cutlery. However, it lasts longer.
Awareness	Combine with proper designs it will increase awareness to use green products.	It looks similar to plastic cutlery; therefore, users might treat it as plastic disposable cutlery.	It will raise awareness to use less disposable cutlery. Maybe more users will bring cutlery from home.

Figure 8 Comparison of Materials

6.0 Recommendations

Through our research, we believe that bamboo cutlery would be the best option to include in the waste-reducing vending products project. In terms of the economical, social, and environmental impacts, bamboo provides the most benefits; however, bamboo is not the objectively best option. In terms of economical costs, manufacturing plant starch utensils costs roughly $0.10 per piece, compared to $0.50 costs of bamboo. Bamboo cutlery also requires a higher level of maintenance compared to stainless steel cutlery. They must be hand-washed, as the high temperature from dish washers are unsuitable for washing bamboo material.

On the other hand, bamboo is a natural product that offers plenty of benefits for the environment. Bamboo produces a large amount of oxygen which is mandatory for the respirations of many different forms of life. Being a type of grass, bamboo is completely biodegradable and does not require any additional planting resources after its initial growth. The benefits of bamboo outweigh its weaknesses. Although plant starch is cheaper, it only lasts roughly 6 months before it needs to be replaced. Bamboo can last up to 3 years, which makes up for its higher initial cost. Bamboo cutlery is growing quickly in terms of popularity as people appreciate bamboo's many helpful traits.

7.0 Conclusion

Despite the recommendation to opt for bamboo, stainless steel and plant starch are still two very viable options, depending on the needs and wants of consumers. For example, if price were the only concern, then purchasing starch cutlery would provide the best cost/quantity ratio. On the other hand, stainless steel cutlery has a well established market, so it would be easier to sell them. It is important to address what qualities are the most important before making a purchase. We believe UBC benefits more from bamboo as UBC strives to create a more self-sustainable system.

Before UBC should fully commit to selling any reusable cutlery, a trial period should be done to sell plant starch, stainless steel, and bamboo cutlery. The different materials should be used in various cafeterias across the UBC campus, not just the SUB. We feel that it is possible students of different faculties may prefer different types of cutlery material. The knowledge students gain from their respective faculties could have an effect on their decision, especially if they have studied sustainability. UBC can cater to these preferences for optimal sales. It is important to choose a material that is not only environmentally friendly and economically viable, but something that people would be willing to purchase.

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