

UBC Social, Ecological Economic Development Studies (SEEDS) Student Reports

An Investigation into Biodegradable Utensils for the SUB Renewal Project

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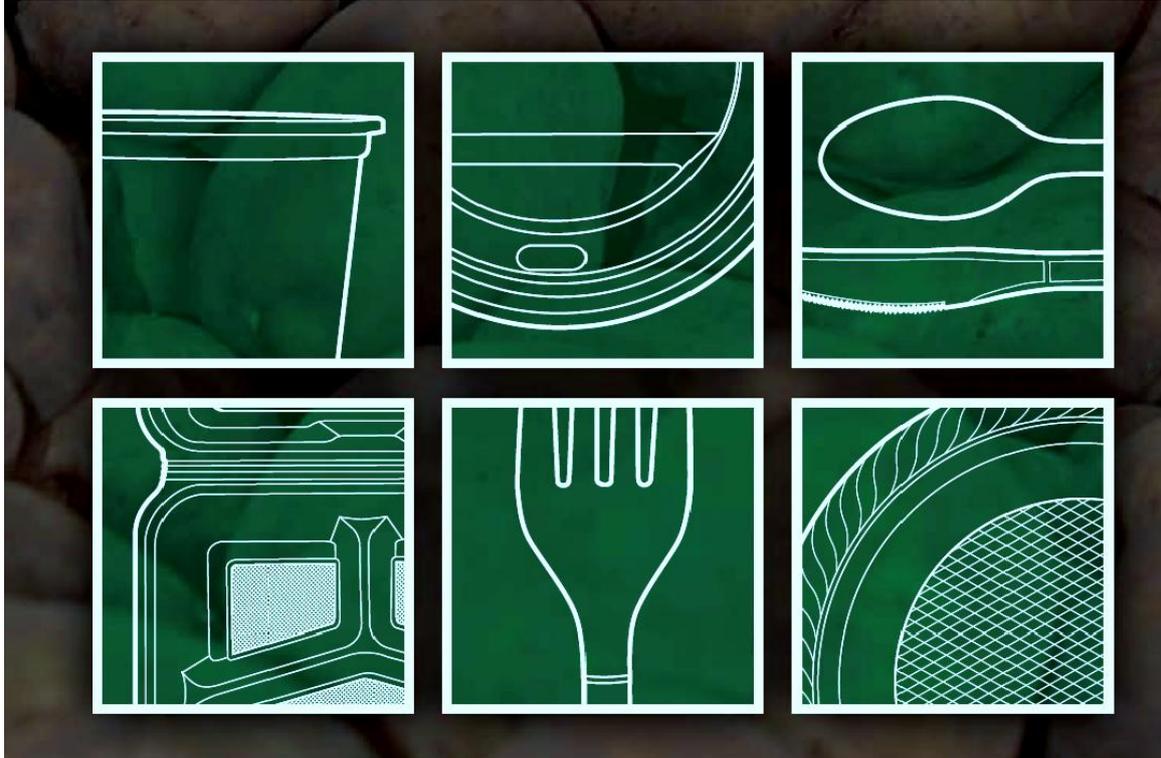
University of British Columbia

APSC 261

November 2009

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for the SUB Renewal Project



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ABSTRACT

In accordance to the planned construction of a new Student Union Building (SUB) on the University of Columbia (UBC) campus, an evaluation is conducted on potential utensils to be implemented at the SUB. The new SUB will accommodate space for offices, clubrooms and most importantly, a new cafeteria. Similar to the current SUB, the new SUB will house more fast food outlets than any other area on campus. Of particular concern is the amount of food waste produced from the SUB. To minimize the environmental impact and head toward a more sustainable future, the focus is put on biodegradable utensils.

This report is an investigation on biodegradable utensils from two companies – Biodegradable Solutions International [BSI] and Biodegradable Food Service [BFS]. UBC Food Services currently purchases utensils from the former. The products of both companies are evaluated in accordance to the triple bottom line assessment. The triple bottom line assessment is a criterion for evaluating the environmental, social and economic impacts of a product. In this report, the assessment is described in a linear manner across the product's life cycle. The life cycle of the products are broken up into the steps of extraction, manufacture, transport and disposal. A thorough qualitative and quantitative analysis is conducted at each step of the product's life. Energy, cost, environmental harm and societal factors are calculated, evaluated and compared.

The results conclude that BFS products are superior to BSI products on all fronts. Calculations show that BFS uses less energy in the production of utensils than BSI. This is due to the fact that BFS uses potato wash as opposed to corn starch as a raw material in production. Potato wash is a waste byproduct that can be collected, whereas corn needs to be grown. Farming corn for industrial purposes raises the market price of corn and contributes to adverse effects on society and the economy. BSI products are also found to be partially incompatible with UBC's in-vessel composter. BFS products, on the other hand, have fulfilled the ASTM D-6400 requirement for composting and are likely to be more compostable. For these reasons, it is recommended for the new SUB to implement BFS utensils as an alternative to BSI products.

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GLOSSARY

American Society for Testing and Materials – an international standards organization that develops and publishes voluntary consensus technical standards for a wide range of materials, products, systems, and services.

Biodegradable – materials capable of being decomposed by biological agents, especially bacteria.

British thermal unit – the amount of energy needed to heat one pound of water one degree Fahrenheit. One Btu is equal to about 1.055 Kilojoules.

Deadweight tonnage – a measure of how much weight a ship is carrying or can safely carry. It is usually measured in long tons.

Degradable – materials that can be chemically broken up into smaller portions.

Ethanol fuel - ethanol (ethyl alcohol) is a type of alcohol. It can be used as fuel for transportation, mainly as a biofuel additive for gasoline.

Handy size – a dry bulk ocean vessel with deadweight of about 15,000–35,000 tons

Injection molding – a manufacturing process for producing parts from both thermoplastic and thermosetting plastic materials. Material is fed into a heated barrel, mixed, and forced into a mold cavity where it cools and hardens to the configuration of the mold cavity.

In-vessel composting – an industrial form of composting biodegradable waste that occurs in enclosed reactors.

Plastic compounding – the process of preparing plastic formulations by mixing and/or blending polymers and additives in a molten state.

Polylactic acid – a natural product created from starches and sugars that decomposes when exposed to water, enzymes, and heat generated by composting.

Poly lactide polymer – a biopolymer made from natural sugar sources that can be used as a substitute for petroleum-based polymers.

Renewable resource – a resource that can be replaced by natural processes at a rate comparable or faster than its rate of consumption by humans.

Starch – a sugar produced by all green plants for energy storage.

LIST OF ABBREVIATIONS

ASTM – American Society for Testing and Materials

BSI – Biodegradable Solutions Incorporated

BTU – British thermal unit

C:N ratio – Carbon-to-Nitrogen ratio

DWT – Deadweight tonnage

FDA – the Food and Drug Administration

KJ – Kilo Joule

PLA – Polylactic Acid

SUB – Student Union Building

UBC – University of British Columbia

1.0 INTRODUCTION

With an increasing demand for products that rely on renewable resources, it is crucial that the new Student Union Building (SUB) operate at the highest level of sustainability. To aid in the reduction of waste ending up in the landfill, UBC has already implemented the use of biodegradable and compostable cutlery at the old SUB. Biodegradable utensils are made from organic material. They have the ability to decompose in a compost site, allowing the waste product to be collected for use as fertilizer or plant nutrition. The ideal biodegradable utensil leaves no waste residue after decomposition and returns viable nutrients back to the ecosystem.

In the following sections, two biodegradable products is assessed – utensils from Biodegradable Solutions International [BSI] and Biodegradable Food Service [BFS]. UBC Food Services currently purchases utensils from the former. The lifecycles of these two products is compared. The environmental, social and economic impact of each product is assessed at each step of the product's life cycle.

2.0 COMPANY BACKGROUND

Biodegradable Solutions Incorporated (BSI) is a Vancouver-based utensils company, specializing in biodegradable and compostable food serviceware. BSI supplies 100% biodegradable and compostable products manufactured from renewable resources. Currently, BSI is the sole supplier of biodegradable utensils to UBC's SUB cafeteria.

Biodegradable Food Service (BFS) is a U.S. company providing environmentally sustainable products that are also claimed to be "100% biodegradable and compostable" to food services (BFS, 2004). BFS manufactures its products from various organic raw materials. For example, the TaterWare line of products, which includes spoons, forks and plates, are made from potato starch. The Bio Cane and Bio Coffee Cups are made from sugarcane. BFS also provides products made from Polylactic Acid, a biopolymer created from natural sugar. The TaterWare products from BFS are recommended for the new SUB due to their superior biodegradable properties over products made from Polylactic Acid (Young, 2009).

3.0 ENVIRONMENTAL ANALYSIS

Environmental sustainability is one of the most important issues UBC faces in implementing products at the new SUB. In the following section, the production cycles for both BSI and BFS utensils are outlined and compared. Energy costs and the composting properties of the products will be the major topics of discussion.

3.1 RAW MATERIALS

BSI utilizes starch from corn grown in China in the production of its utensils. Chinese farmers harvest corn and then send it to a milling plant. In the milling plant, machines cook, grind and screen the corn to isolate its starch. The corn is then left to ferment, whereby microorganisms convert its sugar into lactic acid. Through a process called polymerization, lactic molecule rings link together to form a long chain of polylactide polymer. The polymer is formed into pellets whereby the pellets are then molded into cutlery (NatureWorks 2009).

The TaterWare products from BFS are made from potato wash purchased in Oregon, USA (BFS, 2009). Potato wash is a byproduct created in the preparation of potatoes. When potatoes are retrieved from the farm, they undergo an intensive pressure wash procedure in which a significant portion of their starch is lost. The starch is extracted from the wastewater and dried so that 98% of the solid content can be used for manufacturing utensils.

The advantage of using potato wash rather than corn starch is that potato starch is salvaged from a waste product, whereas corn must be grown. Thus, extracting potato starch eliminates the need for any additional sources of energy or resources. The labor and energy required to farm corn far exceeds that required to obtain potato starch. The average labor input for the farming of corn (in the Liaoning province of China) is around 1252 human hours per hectare (Dazhong & Pimentel, 1984). Although this figure is referenced from an older source, when farming practices were more labor intensive and less mechanized, it provides a sufficient estimate. In addition, the farming of corn requires the use of tractors, pesticides and fertilizers. The chemicals in fertilizers contain phosphorus, a non-renewable resource. The contents of pesticides include toxic chemicals harmful to the

ecosphere. Tractors and agricultural machinery utilize fossil fuels, producing significant amounts of greenhouse gas. Thus, the process of obtaining raw materials for BSI products is much less sustainable than the extraction of raw materials for BFS.

3.2 MANUFACTURING PROCESS

For both BFS and BSI, the raw material is first converted to resin and put through a plastic compounding process. The compounded material is then sculpted into the desired shape through thermal injection molding. Thermal injection molding typically requires 0.9 to 1.6 kwh of energy per kg of product produced (Knights, 2008). For the purpose of this analysis, it is assumed that an average of 1.25 kwh (4500kJ) of energy is used per kg of utensils produced. 75% of BFS products are manufactured in China, while the rest (25%) are manufactured in Gresham, Oregon [BFS, 2009]. In contrast, 100% of BSI products are manufactured in China. The structure of China’s power industry differs significantly from that of Oregon, USA. In China, thermal plants account for 82.64% of the total power output, while renewable resources such as hydroelectric and wind power take up only 17.3% (Hui, 2007). In contrast, 72% of the power generated in Oregon originates from hydroelectric plants and renewable resources (EERE, 2008). Thus, BSI uses up a larger percentage of its energy consumption from non-renewable resources than BFS.

3.3 TRANSPORTATION

After BSI utensils have been manufactured, they are shipped by ocean freight to Vancouver. The products are stored in BSI’s Vancouver distribution warehouse and delivered to UBC via trucks (see Figure 1 below).

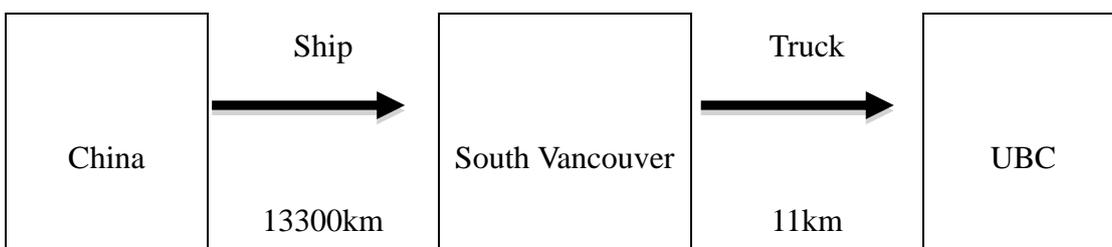


Figure 1. BSI Product Transport Route.

25% of the raw material BFS purchases are transported, via truck, to a plant in Gresham, Oregon for manufacturing (see Figure 2). The other 75% of the raw material is shipped to China. After manufacturing, the completed product is transferred back to a warehouse in Renton, Washington for storage. When a distributor in North America purchases the product, the utensils are then shipped to the distributor’s warehouse. Enterprise Paper, Inc is currently the supplier of BFS products in Greater Vancouver. It is based in Coquitlam, British Columbia and sells BFS’s TaterWare products. When UBC decides to purchase BFS products, the utensils will be trucked from Enterprise Paper.

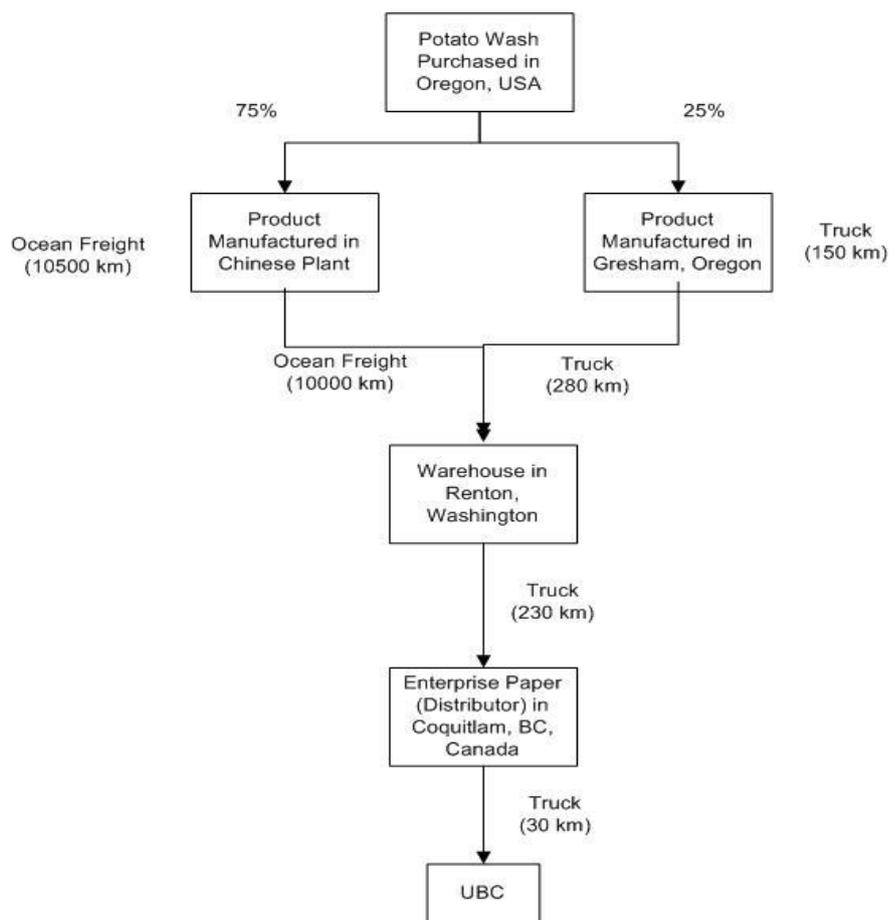


Figure 2. BFS Product Transport Route.

3.4 ENERGY REQUIREMENT IN TRANSPORTATION

The energy utilized in transporting a product (and its raw materials) in the various steps of its life cycle represents a significant portion of the total energy it expends in its lifetime. Such methods of transport include ocean freight and truck, both of which rely on non-renewable fuels. For the purpose of simplifying this analysis, assume that road transportation is undertaken by heavy cargo trucks with a fuel economy of 2,426 kJ / ton-km [Wikipedia, 2009]. A standard cargo truck has a

maximum capacity of 30 tons. Ocean freight is most likely to be embarked by handy size cargo ships. A handy size cargo ship has an average DWT (Deadweight tonnage) of 35,000 tons and a fuel economy of 370kJ / ton-m. An estimate of the total energy utilized by a BSI product to make its trip from China to UBC is illustrated in Figure 3, below.

	China to Vancouver	Vancouver to UBC
Transportation Mode	Ocean Freight	Freight Truck
Distance (km):	13,300	11
Cargo Capacity (tons):	35,000	30
Fuel Consumption:	370 kJ/ 1ton-km	2,426 kJ / 1ton-km
Energy Consumed:	$(13,300\text{km})\left(\frac{370\text{kJ}}{1\text{ton} \cdot \text{km}}\right)$	$(11\text{km})\left(\frac{2426\text{kJ}}{1\text{ton} \cdot \text{km}}\right)$
	= 4921,000 kJ/ton	= 26686 kJ/ton
	= 4921 kJ/kg	= 26.686 kJ/kg
Total Energy:		4947.7 kJ/kg

Figure 3. BSI Transportation Energy Requirements

BFS products travel two routes, depending on where it is produced. If the raw material is part of the 75% being shipped to China, that batch of BFS utensils would need to travel halfway around the world. An estimate of the total energy utilized for transporting BFS products is illustrated in Figure 4 below. The distance and resulting energy calculations are taken from the average of the China/Oregon paths based on the 75%-25% ratio.

Supplier	Ocean Freight	Freight Truck	Total (Ship + Truck)
China path	20500 km	260 km	$(20500+260)*75\% = 15570$ km
Oregon path	0 km	690 km	$690*25\% = 172.5$ km
Average China/Oregon Paths (75%-25% ratio)	15375 km	367.5 km	100% = 15742.5 km
Fuel Consumption:	370 kJ/ ton-km	2,426kJ /ton-km	
Average Energy	$(15375\text{ km})\left(\frac{370\text{kJ}}{1\text{ton} \cdot \text{km}}\right)$	$(367.5\text{ km})\left(\frac{2426\text{kJ}}{1\text{ton} \cdot \text{km}}\right)$	6580.305 kJ/kg
	= 5688750 kJ/ton	= 891555 kJ/ton	
	= 5688.75 kJ/kg	= 891.555 kJ/kg	

Figure 4. BFS Transportation Energy Requirements

3.5 TOTAL ENERGY REQUIREMENT

The total energy required in the life cycle of a kilogram of BSI products is illustrated in Figure 5. It should be noted that the majority of the energy used stem from transportation needs. Despite the fact that a significantly less amount of energy would be consumed if the utensils were produced locally in North America, companies usually prefer the China route due to the low cost of labor and farming. These practices of economy have significant negative effects on the environment.

	Total (kJ/kg)
Farming	2136
Manufacture	4500
Transportation	4947.7
Total (kJ)	11583.7

Figure 5. BSI Total Energy Requirements.

The total energy required if decision is made to purchase BFS products is illustrated in Figure 6. Assuming that 31% of the electricity utilized during the manufacturing process originate from renewable resources, it can be calculated that 1395kJ (12.6% of the total energy utilized) are environmentally sustainable. This figure is small due to the large proportion of energy spent on the product’s transportation, which is unlikely to use a renewable fuel.

	Total (kJ)	Renewable Resource (kJ)	Non-Renewable Resource (kJ)
Transportation	6580.305	0%* 6580.305 = 0	100%* 6580.305 = 6580.305
Manufacture	4500	31%*4500 = 1395	69%*4500 =3105
Total (kJ)	11080.305	1395	9685.305

Figure 6. BFS Total Energy Requirements.

3.6 COMPOSTING PROPERTIES OF PRODUCTS

Composting is the decomposition of organic matter by microorganisms such as bacteria, yeast or fungi. A compostable material typically undergoes biological degradation for 2-3 months and produces carbon dioxide, water, inorganic materials and biomass. Composting occurs naturally and allows the return of vital organic matter and nutrients to return to the soil. In a compost site, these nutrients can be collected for use as fertilizer material. A biodegradable material is capable of being completely broken down by microorganisms. A biodegradable material is a subcategory of a compostable material.

Composting requires four major chemicals: carbon, nitrogen, oxygen and water. Bacteria in the compost pile oxidizes the carbon in waste matter into carbon dioxide and water. Bacteria heats up the material as they work through the waste material, and water is typically released as steam. The carbon to nitrogen ratio is a crucial factor in evaluating compostable materials. The carbon: nitrogen ratio must be delicately balanced: if the material is too low in nitrogen, the bacteria will not be able generate significant heat. If it contains too much hydrogen, the compost may heat up too much. Overheat can kill compost microorganisms and deprive the material of oxygen. The ideal C:N ratio of the decomposed material should be around 10:1 [Richard/Trautmann, 1996].

3.6.1 Composting Properties of BSI Products

BSI's utensils are mentioned to be 100% compostable in a commercial composter (BSI 2009). The University of British Columbia operates an in-vessel composter on campus, enabling a wide variety of waste material, such as BSI's utensils, to be composted. Assessing the compostable viability required the analysis of the utensils after the composting process. It is found that, at the moment, compostable utensils supplied by BSI are not fully degrading at UBC's in-vessel composter. It is suggested that the utensils are too thick, and that in order to compost fully, the utensils must be shredded first (Beauder 2009). However, shredding the utensils prior composting is an added cost and requires further labor. Upon exit from the in-vessel composter, the intact utensils are gathered and eventually sent to the landfill (Beauder 2009). BSI utensils have not met the compostable criteria as UBC has hoped, primarily due to the fact that UBC's in-vessel composter is not as efficient or

advanced as commercial composters. Sending the partially decomposed utensils from BSI to a commercial composter would require extra energy and cost, something that UBC is not willing to undertake. Thus, the majority of the biodegradable utensils UBC purchases at the moment are not being properly treated to be environmentally sustainable.

3.6.2 Composting Properties of BFS Products

BFS has performed industry standard testing of its products according to the ASTM D6400 Standard [BFS, 2009]. The ASTM develops international standards for materials and products used in construction, manufacturing and transportation [ASTM, 2009]. The ASTM D6400 specification provides a standard for testing aerobic composting, or composting under conditions with oxygen (as opposed to anaerobic composting). The specification covers plastics and plastic products designed to decompose in municipal and industrial composting facilities. Sample test sheets from BFS were allowed to compost for 90 days at $58 \pm 2^\circ\text{C}$ with direct contact in a compost medium [BFS, 2009]. The control used in the test was cellulose. Temperature, aeration and humidity were closely controlled and monitored. The assessment determined the degree and rate of aerobic biodegradation. It was designed to produce repeatable test results regardless of the microorganisms present in the composting pile. In addition, test results yielded a percentage of conversion of carbon in the sample to carbon dioxide (See Figure 7 below). The results of the test can be summarized to the following:

- The composting medium had a Carbon: Nitrogen ratio of 14:1.
- The pH of the compost material was 7.2 (relatively neutral).
- After drying the compost matter at 105°C , the total amount of solids was found to be within the 50-55% range.
- The volatile solids had a dry matter content of 30%, under the maximum of 70% allowed by ASTM regulations.

	(%) Carbon to CO ₂	% Weight Loss	% Biodegradation
Positive Cellulose	98.97%	100.00%	100.00%
Control			

Molded Test Sheet	98.39%	100.00%	100.00%
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Figure 7. BFS Product Composting Test Results (BFS, 2009)

4.0 ECONOMIC ANALYSIS

As this is an investigation on the life cycle of utensils, the economic impact on both the producers and the consumers are discussed. Distributors of the products, the cost of raw materials and the price of products are shown in the following section. In addition, the economic impact of extracting raw materials is also assessed.

4.1 ECONOMIC IMPACT OF RAW MATERIAL EXTRACTION

BSI products are made from corn, a raw material that needs to be grown on farms in China. Growing corn for the purpose of starch extraction has an effect on the Chinese corn market. Corn is primarily used as a staple food in China. Using corn for commercial purposes, such as fuel (in ethanol), animal feed and the production of bio-plastics disturbs the competitive price of corn. The price of corn is likely to grow as a result of the increase in demand.

4.2 COST OF UTENSILS

Enterprise Paper, based in Coquitlam, British Columbia is the distributor of BFS in Greater Vancouver. It provides TaterWare Forks, Spoons and Plates at a bulk quantity and pricing. The cost of all three products, quoted from Dave Leeson of BFS, is 1000 pieces per pack at \$44.16 Canadian/pack. BSI has its own distributor in Vancouver. BSI currently provides corn-based utensils of forks, spoons and plates at 1000 pieces per pack, at \$44.00. BSI has a slightly lower cost when compared to BFS.

By comparison, a batch of 1000 petroleum-based plastic utensils has a price of \$41.60 per 1000 pieces [wholesalerscatalog.com, 2009]. The difference in price between each of these products is negligible. However, the shelf price of the products cannot be the sole factor in deciding which

product to purchase. BSI products, for example, have found to be incapable of completely decomposing in UBC's in-vessel composter. UBC is required to spend extra money in picking out the remains of partially-decomposed BSI utensils and transport them to the landfill.

5.0 SOCIAL ANALYSIS

The social impacts of both BSI and BFS products are discussed in this section. Advantages and disadvantages of the products, including usability and disposal are compared.

5.1 RAW MATERIALS AND SOCIETY

The raw materials utilized by BFS are byproducts of agriculture; thus, BFS utensils do not contribute to added waste in society. Potato starch is also sold for cattle and hog feed in some companies. On the other hand, BSI products are made from corn. Displacing corn used as food to manufacture bio-plastics makes corn products more expensive for Chinese consumers. This is a problem, considering that corn is one of the four major species of staple food in China.

5.2 EASE OF USE OF UTENSILS

The TaterWare products from BSI are suitable for both hot and cold food. They are heat stable up to 420 ° F. In addition, they are safe for freezers and microwaves. All Tater Ware products have premium design for strength. For example, TaterWare Dinner & Salad Plates are designed with an embossed diamond pattern for extra strength. Different sizes of TaterWare containers, dinner and salad plates are available for a variety of colors. In addition to TaterWare, BFS also offers a variety of other biodegradable food service products with great usability. These include Bio Coffee Cup (for hot liquids), Bio Grade 300 (for other hot foods), Bio Wrap (a biodegradable, heat-resistant food wrap), and NatureWorks PLA (for cold food and beverages only).

BFS products meet the FDA (Food and Drug Administration) food contact requirement. All TaterWare components had been submitted to the FDA for approval and all ingredients meet the FDA requirement for direct food contact. By submitting TaterWare product components to the FDA, BFS are able to ascertain a 4 million dollar insurance policy to protect distributors and brand owners.

Unlike BFS products, BSI products are not recommended for hot food. BSI utensils are only heat sustainable up to 135 degrees. Thus, they are only limited to cool or mildly warm foods such as salads. UBC currently utilizes a combination of biodegradable (BSI) cutlery and non-biodegradable petroleum-based cutlery. In order to completely utilize biodegradable materials, it would be sensible to switch to BFS products instead.

5.2 SOCIAL EFFECTS OF DISPOSAL

The proper discarding of utensils is of social importance. The disposal of the utensils into either the garbage or recycling bin defeats the purpose of its compostability. The garbage bins lead to the landfill, where composting does not occur. In the recycling bins, biodegradable plastics are usually mixed with petroleum-based plastics. Even though some of these petroleum-based plastics may be degradable, it does not mean that they are *compostable*. Degradable plastics merely have the capability of chemically breaking down into smaller components – they do not return organic matter back into the soil. Therefore, the discarding of cutlery into the recycling bins requires manual sorting. Awareness on these subjects is important. Students often discard their entire meal into the bins without the proper sorting and disposal of recyclables and compostables. Thus, to eliminate the need of sorting, UBC's new SUB would need to implement a 100% bio-degradable solution from BFS.

6.0 CONCLUSIONS AND RECOMMENDATIONS

The triple bottom line assessment of both companies yielded similar results; BFS products, however, are shown to be slightly superior on all fronts.

In examining transport routes, the energy of transport was calculated. The utensils by BFS follow a longer transport path, resulting in a higher transport-energy-usage. The one-way route of BSI's products as opposed to the two-way route for BFS means that BSI products are more energy efficient in that aspect. However, the added energy of growing corn results in BSI's total energy usage to be higher than BFS'.

Both BSI and BFS claim that their product is 100% compostable in a commercial composter. BFS's utensils are certified to be compostable by ASTM standard requirements. These requirements were not obtained from BSI. Moreover, a post-compost examination of BSI's cutlery proved unsatisfactory. Based on the products' viability for composting, BFS's utensils are recommended.

The reduction of waste has a positive effect on society. By using potato wash, BFS helps to reduce agricultural waste. In contrast, BSI's practice of farming corn drives up corn's market price. On a broad scale, BFS products provide more societal benefits than BSI products.

The price differences between both products are negligible. There is a difference of 16 cents per case of the utensils. However, in the long run, BFS products are recommended for their lower cost of disposal. This is due to the fact that UBC currently uses extra money to dispose of partially decomposed BSI products.

With the exception of the cost per case of utensils, BFS has out-matched BSI in all categories. It is highly recommended that the new SUB building at UBC implement BFS utensils as an alternative to BSI products.

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