Investigating the Production of Alternatives to Single-Use Plastic Products in Vietnam

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Abstract

Single-use plastics (SUPs) have been the focus of plastic pollution control, and limiting their use while shifting to other alternatives has been widely promoted in various countries. In Vietnam, between 2.8 to 3.1 million tons of plastic waste are estimated to be discharged on land every year, which makes the country one of the world's major sources of plastic litter. Along with many countries around the world, the Government of Vietnam has committed to taking strong actions to reduce plastic waste. To support plastic pollution control, a survey of enterprises producing alternatives to SUP products in Vietnam was undertaken. Our survey results showed that for most SUPs, alternative products were already produced in Vietnam's market. However, alternative products are currently often higher priced than their respective SUP products. The number of enterprises producing alternative products is relatively small, and most of them are small and medium-sized enterprises. The market for alternative products is small when compared to conventional plastics. The demand for alternative products mainly comes from foreign customers (exports) or domestic businesses (restaurant chains, hotels, food business chains, entertainment businesses, airlines). Promotion of alternative products through various policies and incentives to compensate for the higher price will be crucial in further reducing the SUP products that are responsible for, by far, the greatest amount of plastic pollution.

Keywords

Single-use plastics, Bioplastics, Alternatives substitution, Developing country.

1. Introduction

Plastics are used in various applications, and their consumption has expanded about 200 times in the last 50 years, growing faster than any other material (WEF, 2016). The plastic global trade reached 369 million tons in 2021.[1] However, such massive plastic production and consumption create serious waste management as well as economic and environmental challenges. In particular, plastic's extremely slow natural degradation rate delays its remediation in landfills. Booming plastic waste has already outgrown our capacity to manage it, and only 9 % has been recycled (Geyer et al., 2017). Mismanaged plastics leak into the natural environment, causing detrimental effects on plant growth, soil invertebrate animals, and bird species (Tan et al., 2023). Plastics also cause severe damage to marine ecosystems; according to a study in the North Atlantic Ocean, the obtained seawater samples contained approximately 5,80,000 pieces of plastic per square kilometer (BezİRhan Arikan and BİLgen, 2019). Being the most prevalent category, the production of single-use plastics (SUPs) takes up half of all plastics (WWF, 2019). Designed from the current throw-away society, SUPs are one of the principal contributors to plastic pollution. In the lately ambitious global commitment to end plastic pollution, the control of SUPs is seen as a matter of priority.[2]

Restricting the use of disposable plastic products and directing to environmentally friendly alternatives is regarded as one of the essential approaches to address plastic pollution. As a kind of typical SUPs, single-use plastic bags have surged in enormous demand up to 4.8 trillion a year worldwide (Tan et al., 2023). Without proper management, plastic bags can block waterways and exacerbate water-related risks, acting as one of the most harmful macroplastics to marine ecosystems (Hardesty et al., 2015). Hence, single-use plastic bags have acted as the focus of the object in the policy control. Banning plastic shopping bags has been commonly issued in Italy, Indian, New Zealand, Kenya, Mongolia, Bangladesh, etc., and bioplastics, biodegradable bags, cloth bags, and paper bags are listed as viable alternatives (Chen et al., 2021, Kumar et al., 2024). As an alternative to conventional petro-based plastics, bioplastics have been proposed as an environmentally friendly alternative, with their market predicted to grow between 20 and 25% annually (Benetto et al., 2015). Recent studies have also shown a favorable shift by the general public toward using bioplastics rather than their petroleum-derived counterparts (Dilkes-Hoffman et al., 2019).

In Vietnam, about 3.9 million tons of PET, LDPE, HDPE, and PP plastics are consumed every year; of these, 1.28 million tons (33%) are recycled, and up to 2.62 million tons of plastic are discarded, resulting in a loss of 75% of the material value of the plastic, equivalent to from 2.2 - 2.9 billion USD per year (WB, 2021). Also in Vietnam, between 2.8 to 3.1 million tons of plastic waste are discharged on land every year (Jambeck et al., 2015), which makes the country one of the world's major sources of plastic litter. Disposable plastic products

[1] Please refer to https://unctad.org/news/scaling-plastic-substitutes-key-tackling-pollution
[2] Please refer to https://www.unep.org/inc-plastic-pollution

are increasingly used in Vietnam, due to their convenience, cheap price and current consumers' behavior. According to the Ministry of Natural Resources and Environment (MONRE), each Vietnamese person disposes more than one plastic bag per day, and the number of plastic bags discharged into the environment annually is about 31.4 billion bags, only 17% of which are recycled. Single-use plastics quickly end up in landfills or being released into the environment due to inadequate waste management systems. Therefore, single-use plastic consumption and plastic waste management have become a biggest environmental problem in Vietnam.

To explore the extent of plastic pollution in Vietnam, a World Bank study was conducted between July 2020 and April 2021 on the different types of plastic waste that leak into rivers and the ocean (WB, 2022b). The study, which included field surveys of riverbank and coastal sites, found that plastic waste accounted for most of the waste collected, of which SUP items comprised 62 percent of the total plastic waste (in number). Plastic bags and their fragments, Styrofoam food containers, and straws were identified as the most abundant SUPs in the environment, accounting for up to 38 percent of the plastic waste leakage at the surveyed locations.

Along with many countries around the world, the Government of Vietnam has committed to taking strong actions to reduce plastic waste. On December 4, 2019, the Prime Minister issued Decision No. 1746/QD-TTg promulgating the National Action Plan for Management of Marine Plastic Litter by 2030. In this National Action Plan, Vietnam's government committed to cutting marine plastic litter by 50 and 75 percent, respectively, by 2025 and 2030. To reach these targets, the government recently introduced a number of laws, decrees, and circulars to tackle SUPs, which are a major source plastic litter. On July 22, 2021, the Prime Minister issued Decision No. 1316/QD-TTg approving the plan on strengthening plastic waste management in Vietnam, with specific goals by 2025: Use 100% environmentally friendly plastic bags at shopping centers and supermarkets to replace non-degradable plastic bags; Strive for 100% of tourist areas and hotels not to use non-degradable plastic bags and SUP products. More recently, Decree 8/2022, which concerns the implementation of a selection of articles in the Law on Environmental Protection 2020, set targets for January 1, 2026, to stop the production for domestic consumption, as well as imports of non-biodegradable plastic bags that are smaller than 50cm x 50cm, and have a thickness of less than 50 µm. This Decree also requires gradual reduction of the production and importing of other SUPs, until all are banned in 2031. In addition, the Decree directs Provincial People's Committees (PPCs) to restrict the distribution and use of SUPs in commercial centers, supermarkets, hotels, and tourism areas, starting in 2025 (WB, 2022a).

To support the implementation of the policies on plastic waste management, the Project "Mitigating marine plastic debris in Viet Nam" is sponsored by WWF-Vietnam and led by Vietnam Administration of Seas and Islands (VASI), MONRE. Within this Project activities, a survey of enterprises involved in production of alternatives to SUP products was undertaken in 2023. Utilizing the survey results, this paper presents an investigation of the

current position as well as the needs of the enterprises regarding their production of alternatives to SUP products in Vietnam.

2. Literature review

The alternatives to single-use plastics can be categorised into two broad groups: material/product alternatives, and system/process alternatives, with a range of alternatives existing within these groups. The first category is related to alternatives in terms of materials and how they are produced, for example, traditional materials such as paper, natural fibres such as bamboo, and materials synthesised from organic materials such as starch. The second category is related to alternatives that are based on systems or processes such as reducing or reusing packaging as well as active and intelligent packaging. This section focuses on different types of alternatives in the first category.

Material alternatives to plastic typically fall into one of three groups—a reversion to more 'traditional' means of packaging, such as metal or glass; using innovative materials, most commonly bioplastics, which look and feel similar to typical plastic packaging but are made from natural materials and may break down differently by being biodegradable or compostable; and non-plastic-mimicking alternatives, such as products derived from wheat or algae. This literature review focuses on investigating bioplastics, which are new, innovative alternatives to SUPs.

In analysing biobased plastics, also called bioplastics, one has to be aware that the term 'bio' can mean quite different things in this context. According to the definition of the industry association European Bioplastics, bioplastics comprise plastic materials that are either biodegradable, bio-based, or both. Specifically, materials are 'bio-based' if they are (partly) derived from biomass and 'biodegradable' if within a reasonable amount of time, they can be broken down by micro-organisms into the natural substances water, CO_2, and compost (European Bioplastics, 2016). It is estimated that one percent of the 359 million tons of plastic produced annually can be classified as bioplastics. As demand is rising, the market for bioplastics is continuously growing and diversifying. Global bioplastics production capacity is set to increase from around 2.11 million tonnes in 2019 to approximately 2.43 million tonnes in 2024 (European Bioplastics, 2019). It is projected that global bioplastics' production capacities grow by 3.35 % on an annual average over 2024 - 2030. This growth results from the combined influence of several factors: general economic growth, an increase in oil prices making conventional plastic production more expensive, a slight decline in prices of agricultural feedstocks as well as the presence of cost-reducing learning effects (Döhler et al., 2022).

Poly(lactic acid) (PLA) is the dominant bioplastic, due to its strength, recyclability, thermal processability, cytocompatibility, and its large-scale production that ensures reasonable cost. Its 3D-printing filament suitability helped its popularity increase. Despite it being marketed as a biodegradable polymer, its slow hydrolysis cannot be considered

biodegradability but only industrially compostability, therefore posing a significant risk for PLA microplastics. The current trend is designing PLA-based polymers suitable for home composting, with blending copolymerization, or composites/nanocomposites . For example, polyhydroxyalkanoates (PHA) or thermoplastic starch incorporation in PLA improves its elasticity and enables composting (Terzopoulou and Bikiaris, 2024). For polyhydroxyalkanoates (PHAs), a fast-expanding class of biosynthesized polyesters, alternative production sources are surveyed, including municipal waste and algae. Cyanobacteria like spirulina convert CO_2 to PHAs, but scaling up these processes and genetically engineering strains for improved polymer yield are ongoing challenges. PHAs' success hinges on scaling up and reducing costs, via optimized extraction and purification processes, with the industry experiencing significant growth (Terzopoulou and Bikiaris, 2024).

Seaweed is gaining popularity as a source for plastics, with startups like Algix, Algopack, B'Zeos, Evoware, Kelpi, and Notpla manufacturing diverse products, including packaging, utensils, marine equipment, 3D printing filaments, and textiles. Unlike agricultural feedstocks, seaweed can adapt to its environment, grows rapidly, and avoids food and water resources competition. Seaweeds also capture and absorb carbon dioxide from flue gas, and accumulate large amounts of polysaccharides, proteins, and lipids for potential bioplastics (Zhang et al., 2019). There are three routes in valorising seaweed in plastics: (i) as-received in composites, (ii) extract polysaccharides such as alginate, carrageenan and cellulose, or (iii) extract building blocks for polymer synthesis like mannitol. Seaweed-based bioplastics show promise in life cycle assessments, exhibiting a lower carbon footprint than PP and a significantly lower carbon footprint than PLA when composted, with minimal impact on land use (Terzopoulou and Bikiaris, 2024).

In recent years, bioplastics have gained attention due to their potential role in creating a fully sustainable and circular bioeconomy (Döhler et al., 2022). As an expression of a growing environmental awareness of consumers, the demand for bioplastics is rising (European Bioplastics, 2019). Foremost, this concerns the branch that is bio-based. Due to their use of renewable instead of fossil-based resources, they exhibit ecological advantages in terms of a lower CO2 footprint and less intense resource depletion compared to conventional plastics. To the extent that they are bio-degradable in natural habitats, they also promise a solution to the increasingly pressing issue of plastic debris on land and sea. Moreover, at least some of the materials have reached a development stage where they can offer (almost) the same technical properties as fossil-based plastics and are therefore suitable for many applications.

On the downside, however, one must acknowledge the currently still very high production costs, which significantly exceed the costs of producing fossil-based plastics. Furthermore, at least with the current generation of food plant-based resources used in bioplastic production, the overall environmental balance is rather mixed: there is potential competition with food production, and the emissions resulting from land use and land transformation can be considerable as well (Döhler et al., 2022). Using renewable

monomers does not ensure that a polymer will have a positive environmental impact (Terzopoulou and Bikiaris, 2024). With the bioplastics' growth, there is concern about their waste management, especially in the current recycling streams. Once considered plastic waste accumulation, biodegradable plastics are now viewed with skepticism due to their potential environmental impacts. It is uncertain if they will decompose in all environments and the appropriate infrastructure isn't present worldwide. Bioplastics will thus require waste selection and reprocessing facility modifications. To avoid contamination and deterioration of the recyclate's properties, it is important to understand novel bioplastics' effects on recycling streams and their compatibility with current recyclable plastics.

3. Research design

One of the main goals of the Project "Mitigating marine plastic debris in Viet Nam" is to promote the production and consumption of environmentally friendly alternatives to disposable plastic products. To better understand the current situation, this study aims at surveying enterprises producing alternatives to SUP products in Vietnam. Our surveyed data was collected from primary sources through face-to-face interviews with a structured questionnaire. The questionnaire includes five main sections: (1) General Information and Perspectives of Enterprises; (2) Description of the enterprises' products which are alternatives to SUPs; (3) Information about market of those products; (4) Challenges and barriers to supplying substitute products for SUPs; (5) The enterprises' opinions on their needs and solutions to promoting the production of alternatives to SUPs.

The survey was conducted in September - October/2023. Letter of invitation and questionnaires were sent to 20 enterprises which were identified as producers of alternatives to SUP products in previous studies, e.g., WB (2022b). The list of 10 enterprises accepted our requests for interviews is presented in Table 1. The surveyed enterprises all are private enterprises; among the surveyed enterprises, 07 enterprises are limited liability companies, and the rest are joint stock companies (03 enterprises). Other than An Phat Holdings Joint Stock Company, which is a leading corporation operating in the field of environmentally friendly plastic production in Southeast Asia, other businesses are mostly small and medium sized enterprises and newly established. There are three enterprises (including EQUO Vietnam Co. Ltd, Mana.st Co. Ltd and Habope Company) established in 2020. In addition to environmentally friendly products, many enterprises have to produce a number of other products to generate sufficient revenues, such as conventional plastic products (Queen Pack Company, Hapobe Company) and food products (VinaStraws Company produces pasta, noodles; and Mana.st Co., Ltd. also sells reed tea, reed milk tea).

Table 1: List of surveyed enterprises

No	Company's name	Address	Type of production
1	Mana.st Co., Ltd	Hamlet 2, Dong But village, Ngoc Liep commune, Quoc Oai district, Hanoi City	Reed straws
2	VietCycle Joint Stock Company	Toyoto Building, 315 Truong Chinh Street, Thanh Xuan District, Hanoi City	Recycled plastic resins and recycled fuels
3	Mitsui Precision Vietnam Company	Thang Long Industrial Park, Unit 16 & 17 Factory Complex for Rent No. 3, Lot P1-A, Dong Anh District, Hanoi City	Recycled plastic resins and recycled fuels
4	EQUO Vietnam Co., Ltd.	Serepok Tower, 56 Nguyen Dinh Chieu, DaKao, District 1, Ho Chi Minh City	Straws made from grass, rice, coconut, sugarcane bagasse, coffee grounds, paper takeaway containers, paper cups
5	An Phat Holdings Joint Stock Company	Floor 15 - 17, PV Oil Building, 148 Hoang Quoc Viet Street, Cau Giay District, Hanoi City	Biodegradable bags, food wrap, knives, spoons, forks, straws, paper cups, lids, bowls, plates, boxes, trays, and gloves
6	Queen Pack Company	638 Ngo Gia Tu, Duc Giang Ward, Long Bien District, Hanoi City	Paper bowls, boxes, cups Bagasse boxes
7	Hapobe Company	698 NVGiap, Phu Do, Nam Tu Liem District, Hanoi City	Bagasse lid, cup, box, tray, plate, bowl Paper bags, cups, cups, boxes, bowls Wooden knife, spoon, chopsticks Biodegradable wrapping paper, bags, film

No	Company's name	Address	Type of production
8	Buyo Company	10th Floor, Pacific Place Building , 83B Ly Thuong Kiet Street, Hanoi City	Biodegradable bags, boxes, bottles, straws, spoons, forks, wrapping paper, bottles, cups, bowls
9	HRK Company	504 Nguyen Tat Thanh, District 4, Ho Chi Minh City	Biodegradable trash bags Bagasse trays and boxes
10	VinaStraws Company	Building 129, No. 51 Quan Nhan, Thanh Xuan District, Hanoi City	Cereal straws Bamboo straws

4. Results

4.1. The single-use plastic alternatives produced by the surveyed enterprises

Table 2 presents summarized information about some material/product alternatives produced by the surveyed enterprises.

4.1.1. Environmentally friendly alternatives to single-use plastic products

- *Bioplastic bags*

To replace conventional plastic bags, biodegradable bioplastics (PLA, PBS...) made from plant-based materials such as corn, tapioca, sugar cane... are imported to produce biodegradable bags. Biodegradable plastic is defined as material that completely decomposes into CO_2, water, and organic matter. Currently, in Vietnam, there are companies that produce biodegradable plastic products with certificates obtained from TUV OK compost INDUSTRIAL, TUV OK compost HOME, (BPI) Biodegradable Product Institute Compostable, and DIN CERTCO compostable. However, the current production cost of the biodegradable bags is about 3-4 times higher than that of conventional plastic bags. To reduce the production costs, biodegradable bioplastics can be mixed with convetional plastics (about 70% of convetional plastics). Currently in the Vietnam's market, there are also oxo-biodegradable bags —plastic bags that break down into small pieces much faster than conventional plastic bags. These types of degradable bags, when released into the environment, will cause concerns because they only decompose into small plastic particles (microplastics). The existence of degradable bags but misleadingly marketed as compostable or biodegradable shows the need for clearly defined regulations and standards to ensure the competitiveness of truly biodegradable bags.

Paper bags are also considered as alternatives to conventional plastic bags. There are many advantages of paper and card as an alternative to single-use plastic packaging, based on its

acceptance by consumers, competitive pricing due to an established manufacturing process and its recyclability and biodegradability. However, there are also some significant limitations to paper, particularly regarding food safety and general functionality. It is not fully sealable and is permeable, which can reduce shelf life. It also offers weaker protection from physical impact. Furthermore, paper has limited reusability, and recycling can be prevented if paper is contaminated with grease, food waste or has a bonded plastic film layer.

- *Food Container*

Styrofoam food containers are a common packaging solution for take-away food. Styrofoam cannot be recycled, and it is not biodegradable. This plastic waste is discharged directly into the environment or disposed of together with other household waste (WB, 2022b).

Alternative products made from traditional materials (i.e., paper, metal, glass), and plant-based materials (e.g., bagasse, bamboo, organic wastes). Environmentally friendly products made from plant-based materials can be completely degradable in the natural environment. However, the disadvantage of these products is that they are vulnerable to fungus and mold. The products made from metal and glass are more durable, but these products will require businesses and consumers to adapt to a reusable model.

- *Straws*

In Vietnam, alternatives to plastic straws are well established and sold in volumes that, although smaller, are comparable to plastic straw volumes (WB, 2022b). This is due customer acceptance, the availability of relatively cheap raw materials for alternatives, and a larger number of producers of substitute products. Table 2 shows various types of straws made from organic materials.

Table 2: Potential material/product alternatives to single-use plastic products in the Vietnam's market

No.	SUP products	Alternatives to SUPs	Enterprise	Ingredient	Characteristic	Price	Market	Advantages and Disadvantages
1	Plastic bags 	Degradable bags from starch 	- An Phat - HRK	Starch base: - PBAT - PLA - PBS	100% biodegradable after 6 months	70,000 - 80,000 VND/kg	- Export - B2B	- High price; - Short shelf life; - Must import raw materials;
		Degradable bags from organic wastes 	Buyo	Organic waste	100% decomposes in the natural environment	Higher than regular plastic but cheaper than PLA, PBAT	- Introduced to the market - B2B	- Does not use starch so it does not affect food security; - No need to import raw materials;
		Degradable bags from starch + recycled plastic 	HRK	- Starch (25%) - Recycled plastic (75%) - Additives	Biodegradable	~ 80,000 VND/kg	B2B	- Cheaper than 100% starch bags, has a longer shelf life
		Paper bags 	Hapobe	Special kraft paper	100% biodegradable	~210,000 VND/ 100 bags	B2B	- Short decomposition time; - Has a certain toughness; - Inconvenient when exposed to water; - Easily wrinkled when impacted by strong force

No.	SUP products	Alternatives to SUPs	Enterprise	Ingredient	Characteristic	Price	Market	Advantages and Disadvantages
2	Styrofoam food containers 	Paper box 	- Hapobe - An Phat	Paper + biodegradable film	100% biodegradable	2 - 10 times higher than plastic	B2B	- 100% compostable multi-layer packaging - Food safety - The price is quite high
		Bagasse box 	- Queen Pack - Hapobe - HRK	Sugarcane bagasse	Biodegradable	1,500 - 2,000 VND/piece	B2B	- Must import raw materials - Price is higher than many EPS boxes
		Metal and glass boxes 	Queen Pack	Metal, glass	Durable	The cost is significantly higher than plastic	Small market share	- Can be used multiple times - High price
		Boxes from organic wastes 	Buyo	Organic wastes	100% biodegradable	Higher than regular plastic but cheaper than PLA, PBAT	- Introduced to the market - B2B	- No need to import raw materials - Quite high durability
3	Plastic straw 	Paper straws 	- Hapobe - An Phat	Paper	Disposable	Equivalent to a plastic straw	Domestic and export	- Easily decomposed - However, it is susceptible to mold

No.	SUP products	Alternatives to SUPs	Enterprise	Ingredient	Characteristic	Price	Market	Advantages and Disadvantages
		Rice flour straws 	- VinaStraws - EQUO	Rice flour	Decomposes after ~60 days	2-3 times higher than plastic	B2B	- Decompose quickly - Be proactive about raw material sources
		Bamboo straws 	VinaStraws	Bamboo	Durability is quite high	600 - 1,000 VND/piece	Domestic and export	- Quite high durability, from 3 - 6 months - Vulnerable to mold
		Reed straws 	Mana.st	Reed	Easily decomposes in the natural environment	2,600 VND/tube	Domestic and export	- Hard, does not fade; - Processing costs are cheaper than bamboo straws; - Difficult to clean for reuse .
		Grass straws 	EQUO	Almond grass, reed grass	Easily decomposes in the natural environment	1,600 VND/tube	Domestic and export	- Easy to preserve; - Can be used for both hot and cold drinks; - Easy to break and crack.
		Coconut straws 	EQUO	Fermented coconut water	100% biodegradable	3,000 VND/tube	Domestic and export	- Has very good hardness and flexibility; - Use with all types of drinks; - No unpleasant odor; - No variety of designs.

No.	SUP products	Alternatives to SUPs	Enterprise	Ingredient	Characteristic	Price	Market	Advantages and Disadvantages
		Coffee straws 	EQUO	Coffee grounds	100% biodegradable	1,600 VND/tube	Domestic and export	- Has a slight sweet aroma from coffee but does not affect the taste of the drink; - No color variety.
		Wood pulp straws 	An Phat	Wood flour	100% biodegradable	1,600 VND/tube	Domestic and export	- High elasticity; - Comfortable; - No color variety.

4.1.2. *Current market of the alternative products*

The market for alternative products is relatively small compared to single-use plastics. Customers of the surveyed enterprises are mainly foreign, and exporting products generate the main sources of revenue. Products of An Phat Holdings Company have been exported to 70 countries and territories around the world, including Europe, the United States, the United Arab Emirates, Japan, Korea, Singapore... Natural straw products of Mana.st Company are exported to Korea, Europe, and North America. VinaStraws Company's products are also exported to Korea and Europe. EQUO Vietnam Co., Ltd. focuses on exporting to the markets of Canada, America, and Australia. Some enterprises (e.g., Hapobe Company) focus on the domestic market. For the domestic market, these enterprises provide products for other businesses that are restaurant chains, hotels, food business chains, entertainment services, and airlines (Circle K, TiniWorld, Vietnam Airlines, Vinamilk, Highland Coffee, Winmart...).

In our survey, some enterprises shared their efforts on being self-reliant in raw materials. Vinastraw Company invents and produces cereal straws made from cassava starch and rice starch to replace plastic straws. Mana.st Co., Ltd. uses reed stems to make natural straws, with zero net emissions. BUYO Bioplastics Co., Ltd. is researching and starting to apply technology to turn organic waste into raw materials. An Phat Holdings Company contributes 51% of capital to Korean TLC Company to produce 100% bioplastic materials as raw materials for the production of the Company's biodegradable bioplastic products. For the other companies, raw materials are still imported from abroad (China, Thailand, Indonesia...) to serve their production activities.

4.2. Enterprises' perceived benefits and challenges in the production of alternative products

Except for products using traditional materials (e.g., paper, metal, glass), alternatives to SUP products are produced from edible feedstocks such as vegetable oil and starch as well as algae, wood, and agricultural wastes, e.g., sugarcane bagasse, corn stover, rice husk, and wheat straw. Compared to conventional plastics, production of bioplastics requires less energy. It should also be noted that bioplastic production costs are less susceptible to fluctuations in oil prices compared to the conventional ones (Kumar et al., 2024).

In our survey, 100% of enterprises agree on the benefits related to saving input costs and waste treatment costs. Cost saving appears to be the direct benefit motivating the surveyed enterprises to invest in alternatives to SUP products. For other benefits related to reducing regulatory compliance costs, approaching Government's environmental incentives, and enhancing the branding image or market expansion, the levels of agreement are relatively lower. Although production of alternatives to SUP products would create environmental benefits to society, it appears that these benefits have not been strongly realized by the enterprises in our survey.

Regarding the difficulties and obstacles in producing alternatives to SUP products, 100% of enterprises said that the production cost is relatively high, making it difficult to compete conventional plastic products; and the level of consumers' acceptance is also low. 90% of enterprises' responses indicate that distribution channels for alternatives to SUP products are still limited. 70% of enterprises' responses show that incentive mechanisms and policies to support the development of alternative products are still difficult to access and lack clarity. Businesses have not been regularly updated on relevant policies as well as specific instructions on the process of applying for operating licenses or environmental licenses due to confusion in determining the type of production within the sub-sectors of plastic or recycling, waste management. Businesses also encounter difficulties in marketing and introducing products in domestic and international markets.

In addition, the administrative process of applying for export and import licenses still has some shortcomings. There are no separate harmonized codes (HS) for plastic substitutes and alternative products. HS codes are part of an internationally standardized system of names and numbers that allow countries to be on the same page when classifying products before export and import.

4.3. Enterprises' opinions on solutions

Regarding policy solutions, 100% of businesses agree with the need for charging fees for disposable plastic products; restrictions on single-use plastic products; promulgating standards/regulations for recognition of alternative products. 100% of businesses also agree with the solution to facilitate businesses' access to capital sources at preferential rates.

Regarding solutions to promote the market, 100% of enterprises' responses indicate agreement with solutions to enhance consumers awareness of alternative products. The solutions of linking with domestic/foreign brands and providing incentives (e.g., tax reduction) were approved by 90% of businesses. Solution related to promoting the application of innovation in design, production and marketing received approval from 80% of businesses.

Specifically, the surveyed enterprises proposed solutions related to policies on restricting single-use plastic products or treating alternative products equally as recycled products. There are 02 enterprises suggesting that it is necessary to implement a ban on single-use plastic products with high levels of pollution such as plastic shopping bags, cutlery, straws, take-away food containers, lids, cups, plates, and cotton-buds. At the same time, stricter tax levels should be applied to companies involved in the production, import and sale of single-use plastic items. Higher tax provides a financial incentive for businesses to convert to environmentally friendly alternatives.

To control substitute products that are not truly effective in minimizing environmental impacts, the Government needs to introduce detailed, specific regulations on raw materials for alternative biodegradable products. In relation to incentive mechanisms, manufacturers

and retailers of sustainable products should be provided with grants, subsidies or tax reductions. These incentives will make the production and sale of environmentally friendly alternatives more economically viable. Businesses also request the Government's support on scientific and technological research to improve alternative products and their production. Funding, grants and collaboration opportunities specifically designed for startups working in sustainable products should also be promoted. This support will encourage innovation and entrepreneurship in tackling plastic pollution.

There are also suggestions that it is necessary to strengthen the role of the Association of Environmentally Friendly Product Manufacturers; as well as to establish an official alliance of sustainable businesses to cooperate with the Government in solving the problem of plastic pollution. This network can promote cooperation and knowledge sharing between businesses committed to sustainable development. Educational efforts in schools need to raise awareness of the adverse impact of single-use plastics on the environment; promote the benefits of transitioning to sustainable alternatives. In addition, enterprises also request support for participating in exhibition activities; communicating and marketing alternative products that replace single-use plastic products in domestic and international markets.

5. Conclusions

Our survey results showed that for most of single-use plastics, alternative products were already produced in the Vietnam's market. However, alternative products are currently often higher priced than their respective SUP products. The number of enterprises producing alternative products is relatively small, and most of them are small and medium sized enterprises. The market for alternative products is small when compared to conventional plastic. The demand for alternative products mainly comes from foreign customers (exports) or domestic businesses (restaurant chains, hotels, food business chains, entertainment enterprises, airlines).

Legal guidance and market information exchange between management agencies and enterprises producing and importing substitute products for SUPs are still quite limited. Therefore, it is necessary to have both administrative and financial policies to promote the production of alternatives to SUP products in Vietnam in the coming time. Promotion of alternative products through various policies and incentives to compensate for the higher unit price, will be crucial in further reducing the SUP products that are responsible for, by far, the greatest amount of plastic pollution.

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