Bioplastic Industry from Agricultural Waste in Thailand

Korawit Chaisu
Panyapiwat Institute of Management, Faculty of Innovative Agriculture Management, Nonthaburi, Thailand
Email: Korawitchaisu@gmail.com, Korawitcha@pim.ac.th

***Abstract*—Bioplastic is eco-friendly degradable plastic that has bio-degradability by microorganisms after disposal as a key property. It is produced from starch-base agricultural waste products such as corn, cassava, potato or sugarcane. Poly Lactic Acid (PLA) is the most widely known categories of bioplastic as it is available commercially in various applications range from films, bags, packaging, electronic parts to specialize engineering or medical plastics. The objective of this paper is to review the opportunities and challenges in sustainability of bioplastic from agricultural products in Thailand. As Thailand is the land of tropical agriculture providing a large number of available agricultural wastes which allows competitive advantage for bioplastic industry. The rich of biomass material supply, research driven resource, and supporting government policy creates bioplastic business opportunity to the country. The combination of input supply and advanced manufacturing resources puts Thailand in a competitive and strategic position as a nation readying itself to become one of the global hubs for the emerging bioplastics industry.**

***Index Terms*—bioplastic industry, agricultural wastes, global hub**

I. What Is Bioplastic?

Bioplastics or biodegradable plastic are plastics or substance derived from organic or renewable biomass sources from agriculture products or microbial such as vegetable fats and oils, corn starch while conventional plastics are made from petroleum. One of bioplastic is Poly Lactic Acid or polylactide (PLA) plastic. PLA is a biodegradable thermoplastic aliphatic polyester derived from renewable resources, such as corn starch (in the United States and Canada), tapioca roots, chips or starch (mostly in Asia), or sugarcane (in the rest of the world). In 2010, PLA had the second highest consumption volume of any bioplastic of the world [1].

Bioplastics are made through a number of different processes. Some use a microorganism to process base materials, such as vegetable oils, cellulose, starches, acids and alcohols. While almost all bioplastics produce less carbon dioxide in production than conventional plastics, they are not necessarily completely green. The methods by which their base materials are grown and the processing involved both impact their product footprint. Many bioplastics also release carbon dioxide or monoxide when biodegrading. Nevertheless, their overall environmental impact is typically lower than that of conventional plastics, and as oil costs rise, their cost becomes more and more competitive. Some biodegradable bioplastics can break down in 180 days, given the right conditions. This capacity is desirable, for example, for outdoors applications where longevity and a reduced carbon footprint in production may be the goals.

In term of global production capacities of bioplastics in 2013 and 2018, the result of Asia will increase from 51.4% to 75.8% (by region) "Fig. 1". It can be seen that Asia need to support and demand on bioplastics, Thailand one of the famous country in Asia that can produce a lot of agriculture products that can produce bioplastics [2].

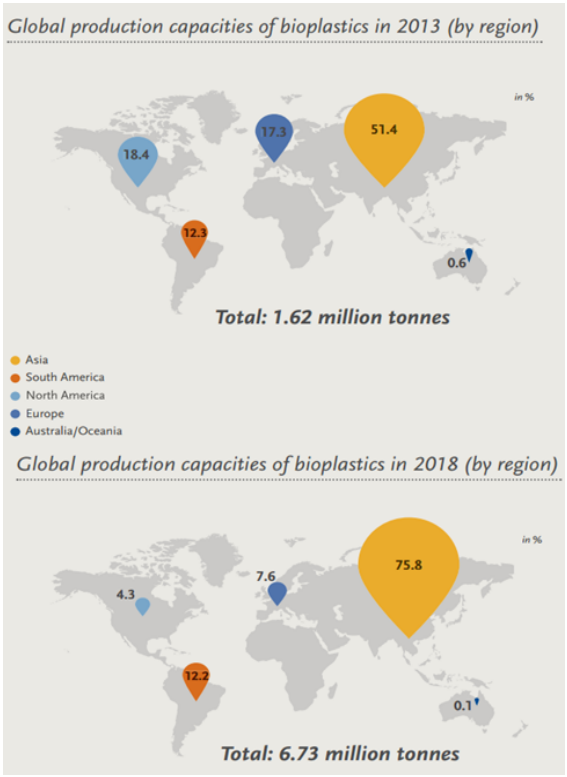

Figure 1. Global production capacities of bioplastics in 2013 to 2018 (by region) [2].

II. Agricultural Products for Bioplasic in Thailand

Thailand has a flourishing agricultural sector in products such as rice, cassava, sugarcane and cellulose and it is the world's biggest cassava exporter and second

Manuscript received December 7, 2015; revised July 27, 2016.

doi: 10.18178/joaat.3.4.310-313

biggest sugar exporter. Manufacturing raw biomass materials into bio-plastics is a profitable, value-added business opportunity that can diversify Thailand's established bioplastic industry and advance Thailand's goal to move its economy up the value chain and compete in world markets.

Moreover, bioplastic can meet the growing demand for biodegradable products in environmentally conscious developed nations. Thailand is transforming itself into an advanced, knowledge-based economy and is moving its manufacturing products up the value chain [3]. The example production of bioplastic products from biomass is shown schematically in "Fig. 2". Cassava is one of the most important economic crops in Thailand. Cassava roots are first transformed into cassava starch, which is then put through a scarification process using enzymes to produce liquid glucose.

The liquid glucose can be fermented by specialized bacteria or fungi to produce lactic acid monomer, which is then polymerized to produce PLA, a biodegradable polymer.

These polymers undergo a compounding process in which its basic properties are modified and enhanced as needed by addition of plasticizers and other ingredients. In the final part of the production process, the material is molded or blown into various types of finished product as needed. Thailand currently has two technologies at industrial levels - saccharification by using enzymes to produce glucose from starch, and molding into finished products. Other technologies are still at the research and development stage [4].

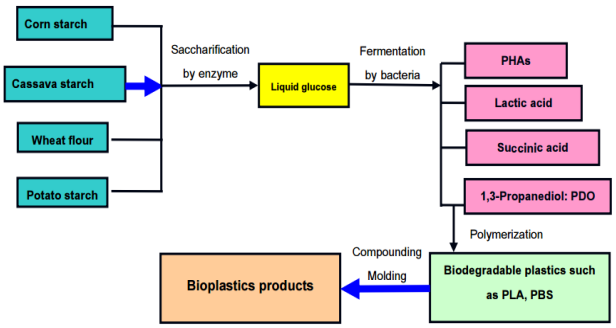

Figure 2. Production process of bioplastics products from biomass.

Microorganism (*Lactobacillus casei* M-15) can produce lactic acid with renewable raw material (molasses) using RSM technique still requires more research efforts to be generalized and applied to a wider scope of lactic acid industries. In addition, the high performance of lactic acid-producing microorganisms, qualified renewable raw materials and effective fermentation processes will be benefit for bioplastic technologies [5].

III. New Bioplastc in Thailand

The new raw material for bioplastic is from waste product feedstock. Waste from the rice milling processes is one of the waste agriculture product approximately 34 % of 1,000 kilogram of rice including rice bran and rice hull (Table I) [6].

TABLE I. The Yield of Rice

Result of rice mill	Average(kg)	Percentage (%)
Head rice	423.17	42.3
Broken-milled rice A-1	173.21	17.3
Broken-milled rice C-1, C-3	66.68	6.7
Rice bran (thoroughly)	72.84	7.3
Rice bran (rough)	29.04	2.9
Rice hull	235.06	23.5
Total	**1,000**	**100**

A. *Thailand's Rice Production Situation*

The overview of rice production in Thailand since 2007/2008 to 2011/2012 was almost 33 million tons of unmilled rice. Thailand can produce unmilled rice approximately 34 million tons in 2011/2012. Therefore, waste from the rice milling processes were around 11.5 million tons (Table II) [6].

TABLE II. Thailand's Rice Production since 2007/2008 to 2011/2012 (Unit: Million Ton of Unmilled Rice)

Order	2007/08	2008/09	2009/10
In-season rice field	23.308	23.235	23.253
Double-crop field	8.791	8.415	8.863
Total rice productivity	32.099	31.650	32.116
Order	**2010/11**	**2011/12**	
In-season rice field	25.442	22.996	
Double-crop field	10.141	11.247	
Total rice productivity	35.583	34.234	

Rice is one of the major agricultural production in Thailand and it can be potential alternative for bioplastic raw material. By using rice bran and rice hull converted to sugar (glucose) and lactic acid on fermentation process (enzyme) respectively. The result indicated that 90%-100% of rice bran can be converted to lactic acid which is better than rice hull that can be converted to lactic acid at 40%-50%. Hence, rice bran consists of efficiency for bioplastic industries [6].

In 2015, Ministry of Industry and Plastic Institute of Thailand has studied biodegradable plastic produced from rice waste called "Rice Resin Project". This bioplastic consist of rice waste for 20% and the project is still during product improvement process "Fig. 3".

Figure 3. Rice resin project.

IV. Supply Chian of Bioplastic in Thailand

Thailand's large presence in plastics manufacturing ensures that there are established industries in every stage of the bio-plastics value chain process, ranging from

biomass processing to bio-monomer and biopolymer industries.

Thailand boasts incredible potential in its established value chain for plastics, from basic intermediates to midstream technologies such as compounding and downstream industries such as molding.

In addition to such capabilities, a lactic acid plant was established in 2007 to produce lactic acid, the main raw material to produce PLA. This ensures that these established plastics industries can be used effectively to manufacture biomass into high-value-added bioplastic "Fig. 4" [3].

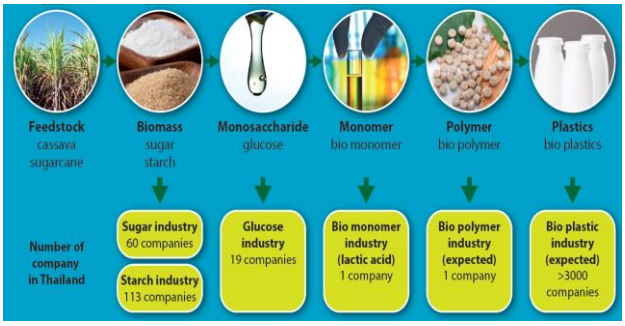

Figure 4. Bioplastic value chain industries.

V. Sustainable of Bioplastic Industry

A. Organization Management

The Ministry of Science and Technology has coordinated with the involved parties to create roadmap to support the investment in bioplastics industry in Thailand. The Public-Private Joint Standing Committee on Science and Technology has agreed to create the supportive measures to enhance the investment in bioplastics industry which, as a result, led to a concrete prototype project in 2013 and commercial investment in 2015 [7]. The main points are as follows:

1. To establish pilot plants with productivity from 1,000 to 10,000 tons/year which are able to operate within 3 years (2011 – 2013). The committee agreed that 300 million Baht supported by the government was required, instead of 1,800 million Baht as granted earlier to co-invest in this industry as 70:30 Private-Public investment. The budget from private sector for a three year pilot project was 1,700 million Baht.

2. To accelerate the process as stated in the roadmap to enhance the commercial investment within 5 years (2011-2015). There are 20 projects in total and they are managed by 33 public and private companies. The budget from private sector for commercial investment is 10,000 million Baht in total, and the budget from the government is 600 million Baht in total.

3. The supportive measure to enhance the commercial investment in 5 years (2011-2015) consists of:

- Measure for Biomaterial Preparation
- Measure for R&D
- Measure for Bioplastics Standardization in International Level
- Measure for Privileges in Investment and Business Functions
- Measure for Market Support and Environment Management

In consequence, Thailand has high capability of organization management that from government and policy.

B. Human Resource Management

Human Resource Management (HRM) is a very important function in bioplastic industries organizations designed to maximize employee performance in service of an employer's strategic objectives [8], [9].

In case of agricultural product waste that can produce bioplastic, the formulating for HR is envelopment friendly or environmental conservation for management nature product to nature.

Thailand's R&D human resource capabilities are high, which enables smooth technological transfer. Furthermore, Thai human resource can innovate new technologies. In the present, there are more than 3,000 plastic processing companies, in which the companies are strong and have high capabilities [10]. Thus, if can create this idea for new generation that certify for sustainable of bioplastic industry and environmental conservation together.

C. Quality of Raw Material Management

Now a day raw material for food is limited. The methodology is selected the quality of raw material from agriculture waste by use HR management to carry on source raw material. The quality of raw material is able to traceability base on the system that similarly to Cheenaphet Supannee, 2015 [11].

D. Processing Management

In term of bioplastic processing technology, under the Ministry of Science and Technology, National Innovation Agency (NIA) and Plastics Institute of Thailand (PIT) are provide and support for universities or companies which concentrate on bioplastic. In addition PIT cooperate international partnership with Taiwan through Industrial Technology Research Institute (ITRI) that can be able to share and exchange knowledge of bioplastic processing management in 2015.

E. Marketing Management

Thailand has been promoting bioplastic study and created road map for bioplastic industry. The network of supporting organizations are including

The National Innovation Agency (NIA) is the core operational organization in facilitating innovation development in Thailand,

- Thai Bio-plastics Industry Association (TBIA): TBIA was founded in 2007 with support from NIA and aims to be the center of information and knowledge in bio-plastics markets and technology.
- The Plastics Institute of Thailand (PITH): PITH, was established in 2010, is an organization under Thailand's Ministry of Industry with aims to support the development of bio-plastics sector by

promoting coordination between public agencies and private firms [3].

There by the bioplastic marketing is one part of the successful in this industry.

F. Finance and Accounting Management

Bioplastic industry in Thailand cannot success without the support from finance and accounting. Thailand's strong agricultural sector, existing plastics industries and supporting governmental organizations make it an ideal location for bio-plastics investment [3]. Besides, The Siam Commercial Bank creates SCB Economic Intelligence Center (EIC) for support not only bioplastic industries but also helping Small to Medium Enterprise (SME). Because of SME in Thailand has limited opportunities in the upstream plastic industry such as bioplastic production as it requires massive capital investment. However, there are abundant opportunities in the bioplastic processing industry in order to serve the domestic and foreign demand from markets such as Europe, USA, and Japan. This is because foreign markets have high demand for bioplastic products especially of bioplastic packaging, which is increasing in popularity [10].

G. Public Relations Management

The public relations management is major factor for disseminate bioplastic industries. It can help to promote bioplastic technology for both domestic and international markets (Digital economy) [12].

VI. Conclusion

Thailand has a flourishing agricultural sector in products such as rice, cassava, sugarcane and cellulose. Various agricultural wastes and bioplastic research provides competitive advantage to bioplastic industry in Thailand. It can create bioplastic business opportunity from the rich of biomass supply and Thai government policy. Sustainable of bioplastic industry can be developed by combination of management such as organization management, human management, raw material quality management. Moreover, the input supply and advanced manufacturing resources puts Thailand in a competitive and strategic position as a nation readying itself to become one of the global hubs for the emerging bioplastics industry.

Acknowledgment

This review paper was supported by Faculty of Innovative Agriculture Management, Panyapiwat Institute of Management, Thailand.

References

[1] H. Chua, H. F. Y. Peter, and K. M. Chee, "Accumulation of biopolymers in activated sludge biomass," *Applied Biochemistry and Biotechnology*, vol. 78, pp. 389-399, March 1999.

[2] European Bioplastics, Institute for Bioplastics and Biocomposites, Nova-Institute, "Frequently asked questions on bioplastic," January 2014, pp. 2-20.

[3] Thai Bioplastics Industry Association (TBIA). (2015). [Online]. Available: http://www.bio-based.eu/iBIB/pdf/20.pdf

[4] National Innovation Agency (NIA), Ministry of Science and Technology, "National roadmap for the development of bioplastics industry (2008–2012)," Approved pursuant to the Cabinet resolution no. 24/2551, pp. 1-55.

[5] K. Chaisu, A. L. Charles, Y. K. Guu, and C. H. Chiu, "Optimization of Poly Lactic Acid (PLA) plastic degradation by *Aneurinibacillus Migulanus* using response surface methodology," in *Proc. International Conference on Biological and Life Sciences*, 2012, pp. 22-27.

[6] S. Sapanuchart, "Bioplastic from rice waste milling process," Plastics Institute of Thailand, 2013, pp. 1-3.

[7] National Innovation Agency (NIA), Ministry of Science and Technology. (2015). [Online]. Available: http://www.nia.or.th/bioplastics/

[8] P. Johnason, "HRM in changing organizational contexts," in *Human Resource Management: A Critical Approach*, D. G. Collings and G. Wood, Eds., London: Routledge, 2009, pp. 19-37.

[9] P. Alan, "Human resource management in a business context," *Thomson Learning*, pp. 1-26, 2007.

[10] C. Suwanna, (8 January 2014). Bioplastic's industry outlook … another business opportunity for Thailand. EIC. [Online]. Available: http://www.scbeic.com

[11] S. Cheenaphet, "Efficiency and agribusiness management of cassava production in Uthaithani Province," in *Proc. WEI International Academic Conference Proceedings*, The West East Institute Barcelona, Spain, 2015, pp. 195-198.

[12] AEC Advisory Pte. Ltd. | AEC Advisory (Thailand) Co., Ltd. (2015). Digital economy: Thailand implications & opportunities for investors. [Online]. Available: http://www.aec-advisory.com

Korawit Chaisu received his Ph.D. in Food Biotechnology from National Pingtung University of Science and Technology (NPUST), Taiwan in 2014. He also earned his Master of Science in Food Biotechnology from NPUST, Taiwan in 2011 and Bachelor of Biotechnology from Maejo University, Thailand in 2009. He is currently a full-time lecturer in Faculty of Innovative Agriculture Management, Panyapiwat Institute of Management, Thailand. His research interests are in agriculture, food biotechnology, microbiotechnology and applied microbial.