Transformation of Cheaper Mangosteen Pericarp Waste into Bioethanol and Chemicals

E.J. Cho[1], H.-J. Bae[1,2]

[1]Bio-Energy Research Center, Chonnam National University, 77, Youngbong-ro, Buk-gu, Gwangju, 61186, Republic of Korea

[2]Department of Bioenergy Science and Technology, Chonnam National University, 77, Youngbong-ro, Buk-gu, Gwangju, 61186, Republic of Korea

E.J. Cho: choej47@gmail.com

The production of bioethanol from biomass has the potential to reduce reliance on imported oil and minimize the negative environmental consequences of fossil fuels (Hafid *et al*., 2017; Whalen, 2017). According to the previous studies, the cost of the biomass feedstock represents a large portion of the total cost of bioethanol production (Huang *et al*., 2015). Therefore, it is necessary to find a candidate material as a cheap feedstock for bioethanol production. The waste-to-energy (WTE) concept is being highly promoted as part of this effort.

Millions of tons of fruit waste are produced around the world annually, becoming one of the main sources of municipal solid waste (MSW), and an increasingly difficult environmental issue. However, only a small portion of fruit waste is recycled and reutilized as animal feed, or fertilizer, or for land spreading (Díaz *et al*., 2017; Kasapidou *et al*., 2015). Thus, the fruit processing wastes can be used as potential candidate feedstock for bioethanol production and this could be an attractive alternative for disposal of the polluting residues (Waghmare and Arya, 2016).

Mangosteen (*Garcinia mangostana L.*) is a popular fruit, well known for its excellent flavor. However, the edible portion of mangosteen is quite small; for every 10 kg mangosteen harvested, more than 6 kg mangosteen pericarp waste (MPW) is generated (Chen *et al*., 2012). The increasing popular consumption of mangosteen fruit has given rise to an abundant amount of discarded MPW. In addition, the pericarp fractions of mangosteen have a significant potential benefits due to the high content of phenolic compounds, which can be efficiently used in food supplements, cosmetics, and in pharmaceutical applications (Shibata *et al*., 2011) considerable economic benefit. Thus, it is indispensable to study the waste utilization of MPW.

In this study, we developed a new method to efficiently convert mangosteen pericarp waste (MPW) into bioethanol and other valuable products such as α-mangostin, and γ-mangostin (Figure 1).

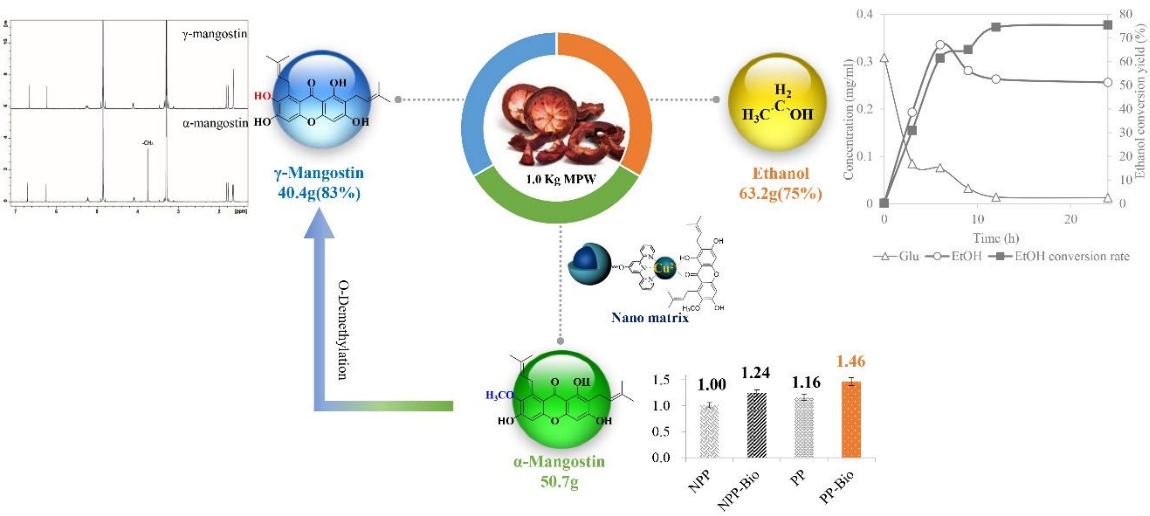

Figure 1. Conversion of mangosteen pericarp waste into value-added products

Mangosteen pericarp is relatively hard, with a thickness of approximately 4-6 mm. Hence, the suitable pretreatment is required to improve the efficiency of subsequent breakdown processes and yields of desired products. Several pretreatment methods were carried out, and the results showed that popping pretreatment was effective in producing high yields of the desired products from MPW.

The popping pretreated MPW was hydrolyzed using a mixture of in-house produced cellulase and pectinase, and the total saccharification rate was approximately 90%. And the biosugar was converted into bioethanol by separate hydrolysis and fermentation (SHF). Ethanol yield from pretreated MPW was 75% of the theoretical maximum (based on glucose levels only) within 24 h. This indicates that MPW is a viable biomass source for bioethanol production. Besides using the MPW as low-cost materials would lower the ethanol production costs.

In addition, the extraction of α-mangostin increased by 1.46-fold after a combination of popping pretreatment and enzymatic hydrolysis. It is much higher than the value obtained from chemical extraction of an untreated sample. A copper-doped magnetic nanomatrix (Cu-MNM) was also utilized to purify α-mangostin from MPW. The magnetic nanomatrix can be reused repeatedly, and the preparation of separation processes is also simple. The chemical structure of purified α-mangostin from ^{1}H NMR was compared to the α-mangostin standard. The purity of isolated α-mangostin was approximately 88.0%. Furthermore, we obtained a good yield of **γ**-mangostin via a o-demethylation reaction of α-mangostin that we obtained from MPW. Thus, the value of MPW can be increased through reuse to produce bioethanol and other valuable active materials.

In summary, we have demonstrated for the first time that MPW is a novel potential raw material for the production of bioethanol and other valuable products such as α-mangostin, and γ-mangostin. The popping pretreatment was effective in producing high yields of the bioethanol from MPW. MPW was converted into bioethanol with yield of 75% using SHF. The use of popping pretreatment and enzymatic hydrolysis facilitated α-mangostin production. Furthermore, high yield of γ-mangostin was synthesized from α-mangostin after o-demethylation reaction. We predict that economically beneficial processes could be developed from the reuse of these waste materials.

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