CHAPTER V

CONCLUSIONS

Biodegradable composite films between cassava starch plasticized with glycerol and crystalline cellulose prepared from agricultural wastes were studied. Two types of agricultural wastes, i.e. bagasse and banana stem, were hydrolyzed with HCl and H_2SO_4. In order to obtain crystalline cellulose, both pulps were delignified, bleached, and then hydrolyzed. The conditions for preparing crystalline cellulose from each agricultural waste were investigated. Subsequently, the prepared crystalline cellulose as well as a commercial microcrytalline cellulose were mixed at 0-40 wt% with plasticized starch. The mixtures were then made into biocomposite films by casting. The effects of particle size, type, and amount of crystalline cellulose on mechanical, thermal, and degradation properties of the films were investigated.

1. The suitable NaOH concentrations for delignification of bagasse and banana stem fiber were 0.5 M and 1 M, respectively. For bleaching step, the suitable condition for both pulps was to use 6% H_2O_2 in alkali solution. In the case of bagasse, the hydrolysis was performed using 2.5 N HCl and 2.5 N H_2SO_4 for 60 min in order to obtain microcrystalline with the average particle size of 12 and 6 μm, respectively. Similarly, banana stem was hydrolyzed with 2.5 N HCl and 2.5 N H_2SO_4 for 30 min resulting in the average microcrystalline particle size of 11 and 7 μm, respectively.

2. The biocomposite films were prepared from plasticized starch and the obtained microcrystalline cellulose as well as a commercial microcrystalline cellulose. The film from plasticized starch without microcrystalline cellulose was also prepared as a reference. It can be clearly seen that the plasticized starch film was a transparent film while the biocomposite films were not as transparent as the plasticized starch films without microcrystalline cellulose. The haze of biocomposite film increased when the amount of microcrystalline increased. In addition, biocomposite film reinforced with commercial microcrystalline cellulose was less transparent than that of biocomposite films reinforcing bagasse and banana stem microcrystalline cellulose. Biocomposite films containing microcrystalline

prepared using H_2SO_4 had higher haze value than biocomposite films contaning microcrystalline cellulose prepared using HCl.

3. The addition of microcrystalline cellulose in plasticized starch improved the tensile strength and Young's modulus significantly. The filler loading which resulted in the maximum tensile strength and Young's modulus was different depending on the microcrystalline cellulose used. Nevertheless, the maximum tensile strength and maximum Young's modulus were in the range of 10-15 MPa and 600-800 MPa, respectively, as comparing with the tensile strength and Young's modulus of plasticized starch film of 2.94 and 137 MPa, respectively. This is due to the difference in the average particle size and the dispersion of microcrystalline cellulose which can be observed by SEM.

4. The biocomposite films have lower thermal stability than the plasticized starch film. However, the biocomposite film reinforcing with H_2SO_4 microcrystalline cellulose started to degrade earlier than that of biocomposite film reinforcing with HCl microcrystalline cellulose. The Td (onset) of biocomposite film reinforcing with bagasse was higher than that of biocomposite film reinforcing with banana stem.

5. In addition, the degree of crystallinity of plasticized starch was higher than that of the biocomposite film. The degree of crystallinity of biocomposite film decreased when the amount of microcrystalline cellulose was increased. The degree of crystallinity of biocomposite films reinforcing with microcrystalline cellulose prepared using HCl was lower than that of the biocomposite film reinforcing with microcrystalline cellulose prepared using H_2SO_4. Furthermore, the degree of crystallinity of biocomposite film reinforcing with bagasse microcrystalline cellulose was lower than that of biocomposite film reinforcing with banana stem microcrystalline cellulose.

6. The water absorption of biocomposite films was higher than plasticized starch film. The water absorption increased as the amount of microcrystalline cellulose in the biocomposite films increased. The water absorption of biocomposite films reinforced with microcrystalline cellulose prepared using HCl was higher than that of biocomposite film reinforced microcrystalline cellulose prepared using H_2SO_4.

7. The biodegradability of plasticized starch film was improved by the incorporation of microcrystalline cellulose. The biodegradability of the biocomposite films increased when the amount of microcrystalline cellulose increased. The biocomposite films reinforced with

microcrystalline cellulose prepared using HCl had more biodegradability than the biocomposite films reinforcing microcrystalline cellulose prepared using H_2SO_4. These results were in agreement with the water absorption.

8. The above results indicated that MMC prepared from both bagasse and banana stem was successfully used to prepared biocomposite film with plasticized cassava starch with the amount of 10 and 30% for bagasse microcrystalline cellulose prepared using HCl and H_2SO_4, respectively, and 20% for banana stem microcrystalline cellulose prepared using HCl and H_2SO_4, being the optimal loading in term of improved tensile strength and Young's modulus while biodegradability of these biocomposite films was also enhanced.

9. Table 5.1 ranked all the physical properties, mechanical properties, thermal properties, and biodegradability of all the prepared films. Among the prepared biocomposite films, the biocomposite film reinforcing with HCl-BG MCC has the highest transparency and biodegradability values. Furthermore, it had higher thermal stability than the other prepared biocomposite films. It tensile strength and Young's modulus were better than plasticized starch and biocomposite film reinforcing with CM-MCC. Therefore, the biocomposite film reinforcing with HCl-BG microcrystalline cellulose is suitable for preparing the biocomposite film for packaging industry.

Table 5.1 Conclusion data of physical properties, mechanical properties, thermal properties, and biodegradable properties of biocomposite films

Sample / properties	Plasticized starch film	HCl-BG / starch film	H_2SO_4-BG /starch film	HCl-BS / starch film	H_2SO_4-BS /starch film	CM/ starch film
Haze	+	++	++++	+++	+++++	++++++
Tensile strength/ Young's modulus	+	+++	++++	+++++	++++++	++
Td (onset)	+++++	++++	+	+++	++	++++++
Degree of crystallinity	++++++	++	++++	+++	+++++	+
% Water absorption	+	+++++	+++	++++	++	++++++
Biodegradable	+	+++++	+++	++++	++	++++++