C. *Physic-mechanical properties of PHilMech-FiC biodegradable fruit bag*

Table III shows the physic-mechanical properties of PHilMech-FiC biodegradable film compared with the low density polyethylene (LDPE) and high density polyethylene (HDPE). The density, water absorption, thickness swelling, tensile strength and percent elongation obtained were 1.40 g/cc, 4.70%, 5.88%, 8.73 MPa and 188%, respectively. The tensile strength is within the range of LDPE while the percent elongation is within the range of HDPE. HDPE and LDPE can be used as packaging, plastic film sheets, containers and among others. Moreover, PHilMech-FiC fruit bag has higher density, thickness and absorbed more water that help to facilitates degradability.

TABLE III
PHYSICO-MECHANICAL PROPERTIES OF PHILMECH-FIC BIODEGRADABLE FILM

Physic-mechanical properties	PHilMech-FiC film	LDPE	HDPE
Density, g/cc	1.38-1.40	0.91-0.94	0.94-0.96
Water absorption, %	3.89-4.70	1.0	1.0
Thickness swelling, %	5.26-5.88	-	-
Tensile strength, MPa	7.50-8.73	4.13-15.86	21.37-37.92
Elongation, %	120-188	100-650	100-130

D. *Biodegradability of PHilMech-FiC fruit bag*

Figure 3 shows the biodegradability of the PHilMech-FiC biodegradable fruit bag and the image before and after burial test. After 17 weeks or more than two months of burial test, almost 50 percent of the biodegradable film was degraded. The rate of degradation was almost three percent per week. After 36 weeks or nine months, the PhilMech-FiC biodegradable will be totally degraded.

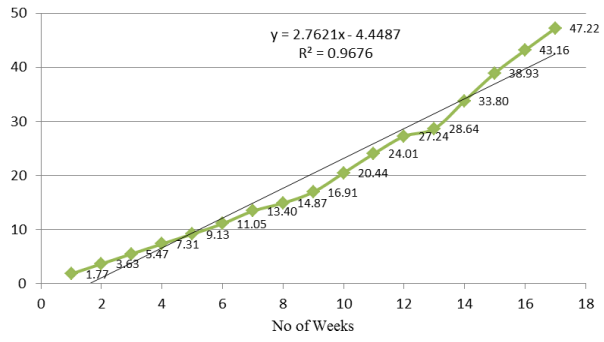

Fig. 3. Biodegradability of PHilMech-FiC biodegradable fruit bag

E. *Field testing and evaluation*

1) Fruit size: Table IV presented the harvested fruits classified into large (290g and up), medium (241 to 289g) and small (190 to 240g). The bagged fruit were classified as medium to large size while most of the unbag fruits were classified as small size.

TABLE IV
CLASSIFICATION OF MARKETABLE FRUITS OF 'CARABAO' MANGO

Treatment	Percent distribution of fruit size		
	Small	Medium	Large/XL
PhilMech-FiC bag	31.07±19.66 [a]	49.90±2.28 [a]	19.17±17.60
Old Newspaper	40.65±24.94 [ab]	51.70±18.62 [a]	7.64±7.40
Chinese brown paper bag	48.92±19.22 [ab]	25.53±5.53 [b]	25.53±22.90
Un-bag (control)	80.78±13.37 [b]	15.05±7.82 [b]	4.17±5.89

Means not sharing letter in common differ significantly at 0.05 level of significance by DMRT

2) Fruit Quality : The external and internal characteristics of the bagged mango fruits were examined individually using National Seed Industry Council (NSIC) evaluation index for 'Carabao' mango (Table V).

The color of bagged fruits, except for Chinese brown paper bags at harvest showed green peel color while un-bag exhibited dark green peel color. This can be associated to the thin waxy material with carbon lining inside, thus, light cannot penetrate and reach the fruit and no protection of fruit to solar radiation. Likewise, peel color at ripening exhibited yellow to orange yellow and no shrinkage on the external appearance of the fruits. On the other hand, the characteristics flesh color, total soluble solids (oBrix) and (% EP) were taken 8 days after harvest. No variation on flesh color and percent edible portion were observed on bagged and un-bag fruits.

TABLE V
EXTERNAL AND INTERNAL CHARACTERISTICS OF FRUITS

Treatment	External		Internal		
	Peel color at harvest	Peel color at ripe stage	TSS (°Brix)	Flesh color	% EP
PhilMech-FiC bag	3.4±0.05[a]	3.3±0.16	7.96±0.47[a]	3.1±0.34	68.57±0.77
Old Newspaper	3.2±0.12[a]	3.3±0.22	19.36±0.47[b]	3.0±0.25	69.48±0.85
Chinese brown paper	1.3±0.24[b]	3.4±0.16	18.89±0.19[ab]	2.7±0.09	69.35±0.45
Un-bag (control)	3.3±0.12[a]	3.3±0.10	18.77±0.62 [ab]	3.0±0.14	67.78±0.94

Means not sharing letter in common differ significantly at 0.05 level of significance by DMRT

3) Causes of non-marketability of harvested fruits: Table VI shows the causes of non-marketability of harvested mango fruits subjected to different bagging materials. The identified causes were physical damaged, insects and diseases damaged. The incidence of physical damaged was evident in un-bag fruit because fruit bagging protect the fruit from physical damage cause by strong winds and rainfall during the production stage.

The insects observed on fruits after harvest were fruit fly, mealy bugs and scale insects. The damaged on un-bag fruits was significantly higher (25.55%) compared to bagged fruits, particularly old newspaper (11.11%). Incidence of high insect damage on fruit bagged using old newspaper can be attributed to the material. Old newspaper could not withstand strong winds and heavy rainfall that destroy the bags hence, greater chances for the insects to damage the fruits. No incidence of insect damage was observed on mango fruit bagged using PhilMech-FiC fruit bag and Chinese brown paper bag.

Scab and sooty molds disease were observed in the mango fruits after harvesting. The damaged cause by diseases on un-bag fruits was significantly higher (13.89%) compared to bagged fruits, particularly old newspaper (11.11%). Incidence of high damaged on fruit bagged using old newspaper can also attributed to the material that could not withstand strong winds and heavy rainfall that destroy the bags hence, greater chances for the insects to damage the fruits. Likewise, no incidence of disease damaged was also observed on mango fruit bagged using PhilMech-FiC fruit bag and Chinese brown paper bag.

TABLE VI
CAUSES OF NON-MARKETABILITY OF HARVESTED MANGO FRUITS SUBJECTED TO DIFFERENT BAGGING MATERIALS

Treatment	Causes of non-marketability (%)		
	Insects	Diseases	Physical damage
PhilMech-FiC bag	0.00±0.00[a]	0.00±0.00	0.00±0.00 [a]
Old Newspaper	11.11±15.71[ab]	11.11±15.71	0.00±0.00 [a]
Chinese brown paper bag	0.00±0.00 [a]	0.00±0.00	0.00±0.00 [a]
Un-bag (control)	25.55±6.67 [b]	13.89±10.39	22.22±15.71 [b]

IV. CONCLUSIONS

Biodegradable fruit bag made of starch and polybutylene succinate (PBS) was developed using a twin-screw extruder and blown film extrusion machine. The PHilMech-FiC bag measured 6 x 8 inches with a thickness of 150 microns. The FTIR spectra of biodegradable fruit bag decreases as the amount of starch increases in the bio-composites. Moreover, AFM modulus images emphasized that reducing the amount of starch facilitated dispersal of starch inside the polymer matrix and inhibits agglomeration of the filler. The tensile strength is within the range of LDPE while the elongation is within the range of HDPE. Likewise, biodegradable film has higher density, thickness swelling and absorbed more water. It is projected that after thirty six (36) weeks, the film will be totally degraded. The quality of harvested fruits using PHilMech-FiC biodegradable fruit bag in terms of peel color at ripe stage, flesh color and percent edible portion is comparable with the existing bagging materials such as Chinese brown paper bag and old newspaper. The developed biodegradable fruit bag material will reduce the use non-biodegradable material in the field agriculture as well as the solid waste being disposed off in landfills.

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