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Techno-Economic Feasibility of Biodegradable Films made from Low Density Poly Ethylene and Modified Corn Starch

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ABSTRACT

This study focuses on the techno economic assessment (TEA) of biodegradable (BD) films made from low density poly ethylene (LDPE) and modified corn starch (MCS). The economic feasibility of the prepared BD films was evaluated by means of break-even quantity (BEQ), and break-even sale (BES). The cost of production for one m^2 BD film was estimated at Rs. 6.76 which is six-fold higher than LDPE film. A calculated cost based on available values in March 2022 at Prayagraj, Uttar Pradesh. The total fixed costs for the production of the BD film include building, land lease value, machinery, and equipment cost. By taking into account the cost of labor, the price of raw materials, the amount of electricity used, and the cost of repairs and maintenance, the total variable cost for the manufacturing of BD film was estimated. The BEQ and BES values for the prepared BD films were estimated 2,52,170.97 m^2, Rs. 17,32,414.29 respectively.

Key words : *Biodegradable film, Circular bioeconomy, Modified corn starch, Techno-economics feasibility*

Introduction

Plastic is used in a variety of sectors as well as household items. Because of its ease of availability, processability, flexibility and seal strength, LDPE is one of the most widely used packaging materials; yet, it has the inherent flaw of non-degradability (Gupta *et al.*, 2010). Statista estimates that global plastics output reached 367 million metric tons in 2020 (Ian, 2011). India creates 15,342 tons of plastic garbage every year, according to the central pollution control board, the year 2018 data with Delhi responsible for 689.5 tons per day. Biodegradable plastics are generated from renewable biomass starch, cellulose, chitosan and protein (Azahari *et al.*, 2011). Because of starch abundant availability, biodegradability, low cost and renewability, starch is one of the most extensively utilized polymers in this category (Heydari and Vossoughi, 2013); (Pushpadass *et al.*, 2010). Amylose predominates in starches, resulting in stronger films (Tabasum *et al.*, 2019), (Nordin *et al.*, 2020).

The TEA allows for both qualitative and quantitative study of the financial viability and technical feasibility of the various stages (Briassoulis *et al.*, 2021). The TEA is required to aid investors in determining the acceptability of the level of risk involved in a project. In various research initiatives, the TEA

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is used to examine the technical and financial aspects of a process that envisions the bulk processing of raw materials for the mass production of marketable products (Chalermthai *et al.*, 2020). A study carried out by Ratshoshi *et al.* (2021) analyzed the TEA of the polylactic acid polybutylene succinate production in an integrated sugarcane factory.

This study analyzes the technical and economic aspect of BD films made from LDPE and modified corn starch. The cost economics of the BD films is discussed from the results of the fixed cost, variable cost, break-even quantity (BEQ), break even sale (BES) values.

Materials and Methods

Techno-economic analysis

The cost of production of the biodegradable film was estimated by considering the fixed and variable costs. The fixed cost was calculated by using the equations 1, and 2 described by Palanisami *et al.*, (1997). The break-even quantity and break-even sale are calculated by equations 3, and 4.

Fixed cost of unit/year = Initial cost of equipment x capital recovery factor … (1)

$$\text{Capital recovery factor} = \frac{R_i \times (1+R_i)n}{(1+R_i)n-1} \times E \quad \text{…. (2)}$$

R_i = Interest rate per year
n = life period of the equipment, years
E = Total cost of machineries

$$\text{Break even quantity} = \frac{\text{Total Fixed Cost}}{\frac{\text{Cost}}{\text{Pack}} - \frac{\text{Variable Cost}}{\text{Pack}}} \quad \text{.. (3)}$$

$$\text{Break even sale} = \frac{\text{Total Fixed Cost}}{\frac{\text{Cost}}{\text{Pack}} - \frac{\text{Variable cost}}{\text{Pack}}} \times \frac{\text{Cost}}{\text{Pack}} \quad \text{.. (4)}$$

The variable cost of the unit was calculated by considering electricity charges, repairs, and maintenance, raw materials, and cost of labor.

Results and Discussion

The cost of land and buildings, as well as the cost of machinery and equipment as stated in Table 1, were taken into account when determining the maximum fixed cost needed to produce a BD film, which came to Rs. 2,16,867.

Production cost of biodegradable film

Fixed cost of machinery and equipment

Total machine cost (E) = Rs. 15,20,689

By assuming, Life span of unit = 15 years
Annual usage of machinery = 300 days
Interest rate/year = 10.5 %

$$\text{Capital recovery factor} = \frac{R_i \times (1+R_i)n}{(1+R_i)n-1} \times E$$

Fixed cost of equipment = Rs. 1,30,467

Cost of land and building

Land and building charges per month = Rs. 7,200
Land and building charges per year = Rs. 86,400
Total fixed cost = Fixed cost of equipment + Building charge
Total fixed Cost = Rs. 2,16,867

Variable cost for the production of BD film

The BD film's production has a variable cost of Rs. 14,86,920. It was calculated that the costs of repair and maintenance, labour, power used by the machinery, and raw materials was, respectively, Rs. 4320, Rs. 2,10,000, Rs. 1,17,600, and Rs. 11,55,000.
Repair and maintenance cost (5% of land charges) = Rs. 4320

- **Labour Charges**

Operator charges/day = Rs. 700
Operator charges/year = Rs. 2,10,000

- **Power consumption**

- Hot air oven = 10kW
- Twin screw extruder and palletizer = 52 kW
- Blown film extruder = 36 kW
- Power consumption per day = 98 kW
- Power consumption per year = 29400 kW
- Cost of total power consumption = Rs. 1,17,600

- **Raw materials**

- Cost of LDPE granules per day = 25kg ×Rs.118 per kg = Rs.2950
- Cost of MCS per day = 5kg×Rs.60 per kg = Rs.300
- Cost of additives per day = Rs. 600
- Overall price of raw material per day = Rs.3,850
- Overall price of raw material per year =Rs.11,55,000

Total variable cost = Repair and maintenance cost + Labor charges + Power consumption charges + Total raw materials cost

Total variable cost = 4,320 +2,10,000 + 1,17,600 + 11,55,000 = Rs. 14,86,920

Total cost for the production of BD film per year

By taking into account both the total fixed cost and

Table 1. Cost of machinery and equipment

S.No.	Name of Equipment	Cost (Rs)
1	Hotairoven	8,069
2	High-speed mixer	1,00,000
3	Twins crew extruder	9,00,000
4	Palletizer	46,020
5	Blownfilmextruder	4,50,000
6	Heat sealing machine	2700
7	Digital weighing balance	13,000

Table 2. Cost evaluation of BD film

S. No.	Particular	Cost/quantity
1	Total fixed cost / Year	Rs. 2,16,867
2	Total variable cost / Year	Rs. 15,15,720
3	Total production cost of BD film/Year	Rs. 17,32,587.9
4	Total production of BD film/Year	2,52,000 m^2
5	Cost of 1m^2 BD film	Rs. 6.87
6	Variable cost/Unit	Rs. 6.01
7	Break-even quantity	2,52,170.97 m^2
8	Break-even sale	Rs. 17,32,414.29

the total variable cost incurred for the production of the BD film, the total cost required for its production was Rs. 17,03,787.9. A one m^2 of BD film was estimated to cost Rs. 6.76 whereas a unit's variable cost was Rs. 5.90.

Total cost for the production of BD film in one year = Total fixed cost + Total variable cost

= 2,16,867.90 + 14,86,920

= Rs. 17,03,787.9

$$\text{Cost of 1 m}^2\text{ BD film} = \frac{\text{Total cost of production}}{\text{Total production per year}}$$

Rs. 6.76 m^2

$$\frac{\text{Variable cost}}{\text{Unit}} = \frac{\text{Total Variable Cost}}{\text{Totol Unit Produced}}$$

$$\frac{\text{Variable cost}}{\text{Unit}} = \text{Rs. } 5.90$$

Cost analysis

With a baseline sale of Rs. 17,04,682.56, the number of additional units of produced BD films that must be sold to recover the cost of an investment is 2,52, 171.97 m^2. Table 2 displays the cost analysis of BD film.

$$\text{Break even quantity} = \frac{\text{Total Fixed Cost}}{\frac{\text{Cost}}{\text{Pack}} - \frac{\text{Variable cost}}{\text{Pack}}}$$

Break even quantity = 2, 52, 171.97

$$\text{Break even sale} = \frac{\text{Total Fixed Cost}}{\frac{\text{Cost}}{\text{Pack}} - \frac{\text{Variable cost}}{\text{Pack}}} \times \frac{\text{Cost}}{\text{Pack}}$$

Break even sale = Rs. 17,04,682.56

Conclusion

The findings of this techno-economic analysis show that producing biodegradable film from the compounding of LDPE with MCS is technically feasible but economically non-viable. The cost of BD film has increased as a result of additional additives, MCS, and lower production rates. The cost-effectiveness of the biodegradable film can be increased by technological advancement, governmental regulations, and research initiatives.

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Conflict of Interest: Hereby, author declares that in current study there is no any conflict of interest.

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