PRODUCTION AND INVESTIGATION OF STARCH BASED BIO PLASTIC REINFORCED WITH COCONUT FIBRE COMPOSITES

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INTRODUCTION

Global per capita plastic consumption is 11 kg/annum. Among developed nations, United States has per capita plastic consumption of 139 kg/annum and Europe has 65 kg/annum. The global Per capita consumption of plastic products is expected to increase with 16-20 kg/annum in 2025 (Tiseo, 2020). The packaging sector is growing fast and the annul demand for plastic is increasing. During one person's lifetime he/she releases a huge amount of plastic that is unbearable to the environment. Most of the plastics remain on the environment for thousands of years. Environmental pollution due to plastic waste accumulation and the long degradation period has become a global problem. Soil, air and water pollution due to plastic waste threatens the life on earth. Single use plastic products and packaging materials have become a threat to the environment. When comparing the usable and degradation lifetime, it is surprising because the usage of the plastic item, lasts for a very short period compared to the degradation time. When designing plastic products, the chemical composition and additives used both for usage and degradation lifetime can be controlled enabling rapid biodegradation at the end of the usage. Considering the global warming and depleting petroleum reserves, attention on alternative renewable resources for production process of bio plastic is vital. Therefore, the focus on alternative renewable resources for production of bioplastic is significant.

1.1 Objectives

- To produce coir fibre reinforced plant-based bioplastics using sweet potato, potato and manioc.
- To determine and compare the tensile properties of bio plastic-coir fiber composites.

METHODOLOGY

2.1. Determination of Starch Percentage of Sweet Potato, Potato and Manioc

Sweet potato, potato and manioc (300.00 g) were taken for extraction. They were washed, peeled and cut into pieces. Then they were blended and filtered twice. Next, these filtered samples were oven dried until constant weight was achieved. After that, 3 samples were tested for each source of starch to get the average percentage of starch. Starch percentage was calculated as below:

$$Initial\ weight = A$$
$$Weight\ of\ empty\ core = X$$
$$Oven\ dry\ weight\ of\ the\ sample = Y$$
$$Weight\ of\ starch = Y - X$$
$$Starch\ percentage = \frac{Y - X}{A} \times 100$$

2.2 Production of Bioplastics

Starch (10.00 g) was mixed with water (50.00 mL) and added vinegar (10.00 mL) and glycerin (5.00mL). One sample was prepared without coir fiber and other samples were prepared by adding 2.50 g and 5.00 g coir fiber. The mixture was heated on a stove and stirred constantly until starch was gelatinized and turned in to translucent gel. Heating was continued until the mixture was clear and transparent. Composites were made by maintaining a constant starch amount with varying fibre concentration. Prepared bioplastic sheets were dried in an oven at 50 ^{0}C for 2 hours.

2.3 Production Process of Bioplastics with Cleaner Production Strategies-Process Flow Diagram (*same process flow diagram for sweet potato, potato and manioc

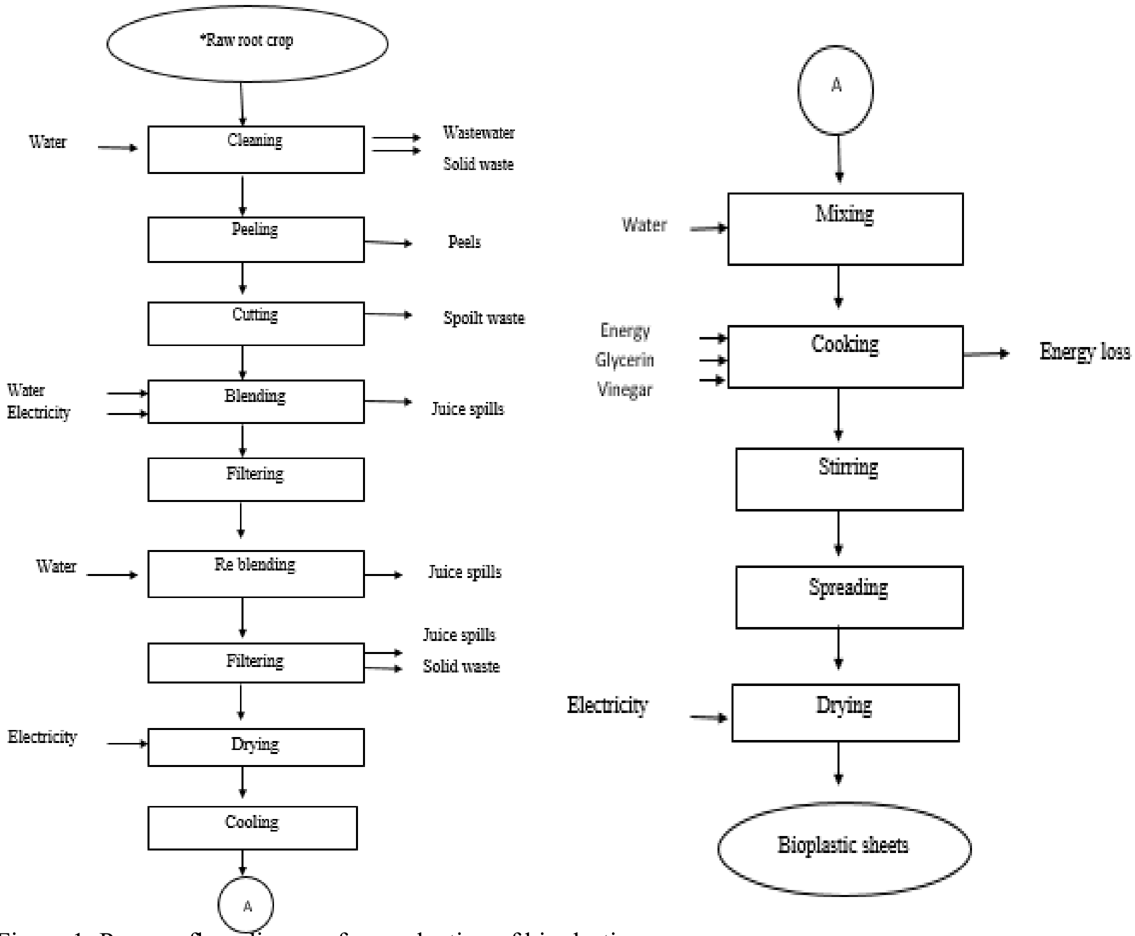

Figure 1: Process flow diagram for production of bioplastic

2.4 Determination of Tensile Strength

The weight needed to break the bio plastic sheet was measured using the Newton Balance. 25 Samples were tested for each bioplastic type and the average values of tensile strength were calculated.

RESULTS AND DISCUSSION

3.1. Determination of Starch Percentage of Potato, Sweet Potato and Manioc

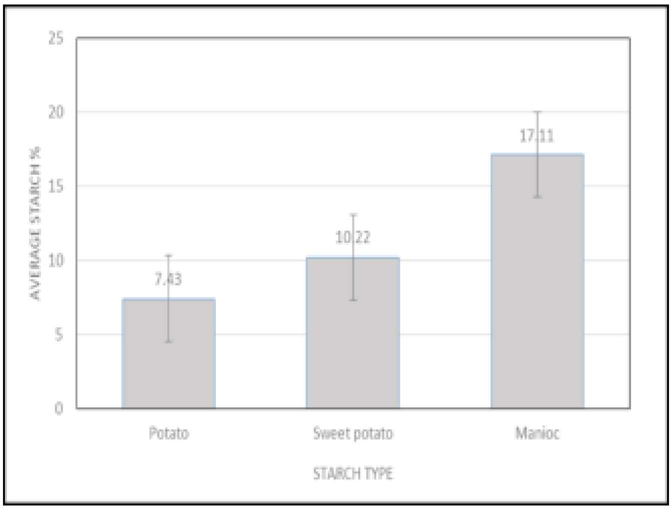

Figure 2:.The average percentage of starch for 300.00 g of 03 samples of potato, sweet potato and manioc

According to figure 2, manioc contains the highest strach percentage compared to the potato and sweet potato starch percentage.

3.2 Quantified Material Wastes (including water) through Material and Water Balance

Quantified material waste was calculated for three types of yams using the following relationship for one batch per month.

$Input = output + known\ waste + unknown\ waste$

For the Production of three bio plastic sheets, the cost for electricity, water and gas consumption are as follows.

Electricity bill - 145 Kw/h = Rs. 3630,Water bill - 13 m^3 = Rs. 262,Gas Cost Rs.1700 per month

The assumptions used in this calculation are 10 sheets produced per day, 20 working days with the assistance of one labourer. All weights are measured in kg

Weight of water = 1 L = 1 kg,Density of vinegar and glycerin = (1 kg/1 L)

Table 1: Material balance for sweet potato based bioplastic

Input	**Amount (kg/month)**	**Out Put**	**Amount (kg/month)**
Material		Material	
Sweet Potato (300 g/sheet)	60	Bio plastic sheet (13.8 g/300 g)	2.76
Vinegar (0.1 g/sheet)	2	Physical waste matter (0.75 g/300 g)	0.15
Glycerin (0.05 g/sheet)	1	Spoilt Sweet Potato (1.5 g/300 g)	0.3
Water (700 g/sheet)	5	Peels (5.8 g/sheet)	1.16
		Solid residue from filtrate (275.5 g/sheet)	55.1
		Unknown losses	8.53
	68		68

Table 2: Total cleaner production potential of the company/ cleaner production quantification and costing for the production of sweet potato based bioplastic Sheets

Total Cleaner Production Potential of the Company/ Cleaner Production Quantification and Costing for Sweet Potato based Bioplastic Sheets		
Material	Cost (Rs.)	Total Cost/month (Rs.)
Raw material cost • **Cost of 300 g (Sweet potato 1kg = Rs.60)** • **Vinegar cost 10 ml (350 mL = Rs. 110)** • **Glycerin cost 5 mL (30 mL = Rs. 60)** • **Total raw material cost per month**	3600 628 2000	6228
Labour cost (Rs. 15000 per month) **Electricity cost per month (145 Kw/h = Rs. 3630)** **Gas cost (Rs. 1700 per month)** **Water cost (13m^3 = Rs. 262)** **Total variable cost per month**	15000 1210 567 87	
		16864
		23092

Total Raw material weight per month = 68 kg
Variable cost per kilogram of raw material = 23092/68 = Rs.340
Counted loss = $8.50 \times 340 \times 10 \times 20$
= Rs. 578000

Other losses = $56.71 \times 10 \times 20 \times 60$
= Rs.680520

(Are calculated based on sweet potato cost = (known waste = 56.71 kg)
Total Cost = Rs.1258520

Total waste profile = 1258520 per month
Total cost of waste for one full year = 1258520×12
= Rs. 15102240

Therefore, Cleaner Production Potential of this company is Rs. 15102240

Similarly, cleaner production potential was calculated for potato and manioc-based bioplastic production and the summarized data are tabulated in Table:3.

Table 3: Cleaner production potential for three bioplastic types

Bio plastic sheet type (0.00 g fibre concentration)	Cleaner Production Potential (Rs.)
Potato	21871248
Sweet Potato	15102240
Manioc	9185040

3.3 Produced Bioplastic Sheets with Fibre

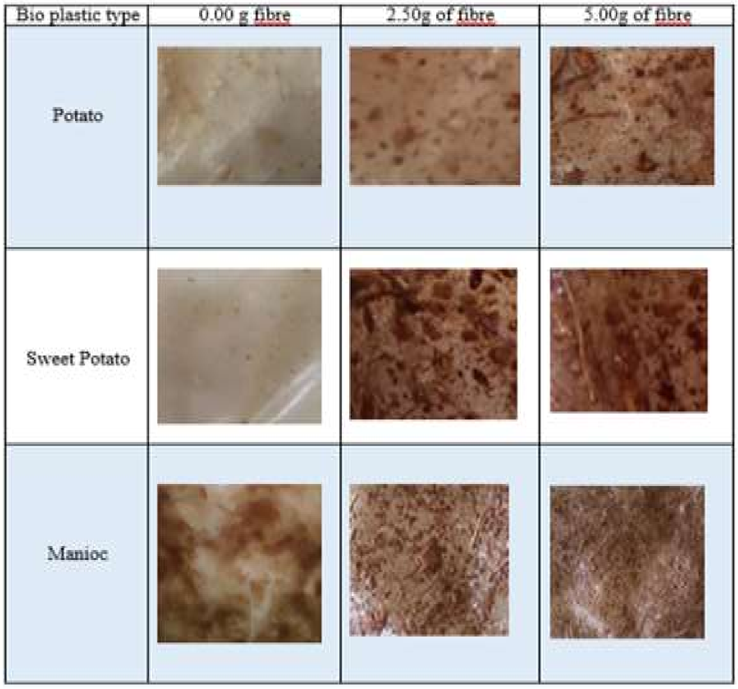

Plate 1:Produced bioplastic sheets reinforced with different amounts of coir fibre (0.00 g, 2.50 g and 5.00 g)

According to Plate 1 the transparency of the bioplastic sheet reduced when the addtion of coir fibre was increased.

3.4 Tensile Strength of the three bioplastics with the fibre content

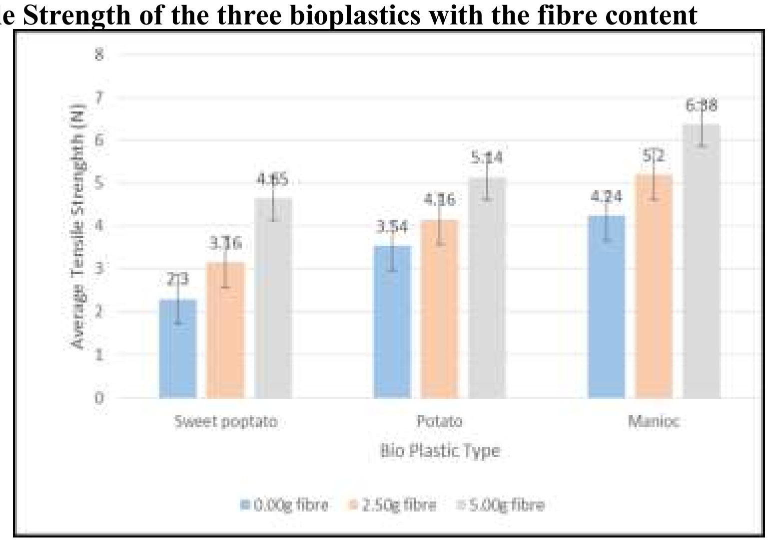

Figure 3: Average Tensile Strength for three bioplastic types with three fibre concentrations with standard error

According to figure 3, manioc based bioplastics have the highest tensile strength compared to sweet potato and potato based bioplastics of three fibre concentrations. The tensile strength of the three bioplastics gradually increased with the addition of fibre and it indicates that high fibre concentration leads to high tensile strength.

CONCLUSIONS AND RECOMMENDATIONS

According to the average values, manioc contains the highest starch percentage while potato contains the lowest starch percentage. Production in an industrial level according to the cleaner production strategies is the best option for bioplastic production. According to the cleaner production potential, manioc-based bioplastics is the most profitable production compared to the sweet potato and potato based bioplastic production. However, the transparency is lesser in manioc based bioplastics when compared to others. The transparency of the bioplastic sheet reduces with increase in coir fibre percentage. The tensile strength of three yams gradually increased with the addition of fibre

RECOMMENDATIONS

Edible packaging material for food items can be produced from starch-based bioplastics by using solely edible ingredients. Production of bioplastic sheets according to the cleaner production strategies are more environmentally friendly. With fibre reinforcement, bioplastic with high strength can be produced to improve the durability and quality of bioplastic

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