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Fabrication and Property Evaluation of Biodegradable Tableware (Plate) Made from Mango Seed Shell

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ABSTRACT

This paper investigates the utilization of mango seed shell as a filler material for the production of bio-composite, which is further used as a tableware. As the mango seed shell is inexpensive, environmental friendly and biodegradable, it becomes a sustainable alternative to other synthetic filler material. The main objective of this study is to fabricate and to evaluate the properties of tableware made from mango seed shell reinforced bio-composite. The composite was fabricated using corn starch with 0, 10, 20, 30 and 40 % weight of mango seed shell powder. The morphological analysis was done using scanning electron microscope (SEM). FTIR is used to analyse the chemical compounds in the developed tableware. Water absorption studies and oil absorption studies were also done. From the experimental results, it has been found that 30% weight of the mango seed shell is considered as the most suitable composition for developing the mango seed shell plates. Therefore the developed bio-composite can be used as a tableware like plates, trays and containers.

Key words: *Mango seed shell, Tableware, Bio-composites, Scanning electron microscope, Morphological properties, Biodegradable*

INTRODUCTION

There is a great concern over the accumulation of agricultural wastes and agricultural by-products in our environment. In order to overcome this problem, waste minimization and recycling of agricultural wastes can be a good solution. Mango (*Magnifera indica* L.) is one of the most important tropical fruits. It is also called as “king of fruits”. In India, the production of mango is 19687000 MT and productivity is 8.7 MT/Ha. Since it is a seasonal fruit, nearly 20% of this fruit is processed for products such as puree, pickles, juices, jam, jelly, leather, nectar, squash and canned slices[3].The waste products of the mango processing industries are mango peel, seed coat and seed kernel. The mango peel is used in the extraction of pectin[8] whereas the mango seed kernel can be used to obtain mango seed oil and starch[5].

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Mango peel and seed kernel are the rich source of polyphenols, dietary fiber, carotenoids and also have antioxidant property. But the mango seed coat, which is otherwise called as mango seed shell is rarely utilized. Only 1 to 5 % of the mango seeds are utilized for raising seedlings[15]. In some cases, mango seed shell is used as an activated bio-absorbent for removal of heavy metals[16]. But in most cases, after processing of mangoes the seed shell goes waste causing problem in disposal and environmental pollution. The mango seed basically consists of two parts. They are outer hard seed shell and inner seed kernel which constitutes 6.11% and 11.69 % of fruit weight[7]. The mango seed, which is 30 to 45% of total fruit weight goes off as waste. About 13,567,563 tonnes of wastes produced in mango processing industries isunexploited[2]. In order to utilize the biological potential of mango seed shell in an efficient way, this experimental study was undertaken. Even the development of polymer based material from mango seeds is considered interesting, since mango is grown all over the world[17]. Mango seed shell has been successfully used as a filler material in the manufacture of composite using recycled high density polyethylene (RHDPE) by compression molding method[1]. To the best of our knowledge, no such research article has been found related to the usage of the mango seed shell as a filler material in making tableware.

MATERIAL AND METHODS

Raw materials:

Mango seed shell (figure 1), rice husk and sugarcane bagasse were collected from local source. It was washed to remove the dirt and impurities, dried in a hot air oven at 60^{0}C for 3 hours and grinded into fine powder. It was then sieved manually in 1.4 mm sieve. The powdered mango seed shell is presented in figure 1.

Fig. 1: Mango seed shell powder

Fig. 2: Mango seed shell plate

Sugarcane bagasse was treated within 2% NaOH solution. Unmodified food grade corn starch was obtained from urban platter and had a moisture content of 10%. Wheat flour and corn flour was obtained from local market and their moisture content are 13.0 % and 12.3 % respectively. A magnetic stirrer is used to form a batter out of corn starch, wheat flour, corn flour, sugarcane bagasse powder, rice husk powder and paper pulp.

The following are the ingredients which was used in this biodegradable plate making process.

Table 1: Ingredients used in developing the plate

Mango seed shell powder (g)	Starch (g)	Corn flour (g)	Wheat flour (g)	Rice husk (g)	Bagasse powder (g)	Paper pulp (g)
0	55	20	10	3	2	10
10	45	20	10	3	2	10
20	35	20	10	3	2	10
30	25	20	10	3	2	10
40	15	20	10	3	2	10

Development of biodegradable plate:

The corn starch (55%, 45%, 35%, 25%, 15%), corn flour (20%) and wheat flour (10%) was mixed along with water and heated at a temperature of 90˚C for 10 minutes. And then the heated mixture was stirred using a stirrer for 25 minutes, at 900 rpm. Different composition of mango seed shell (0%, 10%, 20%, 30% and 40%) were added and mixed thoroughly. Rice husk (3%) and treated sugarcane bagasse (2%) was also added. Waste paper, which is soaked in water for 30 minutes was also added and stirred continuously at room temperature for 15 minutes.

Biodegradable plates were made using a lab model wafer making machine. This machine consists of two heated molds, in which the top mold must be hand pressed, in order to meet the bottom mold, during the process. The diameter of the mold is 21 cm wide. A plastic syringe of 10 ml was used to pour the batter (mixture) into the mold. The baking temperature was 250 ˚C, whereas the baking time was varied from 3 to 5 minutes. After the baking process, desired shapes can be made by cutting the edges of the plate.

Characterization:

FTIR Analysis:

FTIR Spectroscopy was used to analyse the surface components and the functional groups present in the sample. The FTIR analysis was done at a range of 4000-450 cm^{-1} and resolution of $4cm^{-1}$

Water absorption studies:

2 g of samples from each proportion of the developed biodegradable plates were weighed (W_0) and soaked in distilled water. The soaking time was maintained for 5, 10, 15, 20, 25 and 30 minutes. After the completion of soaking time, the sample was taken out of the water, wiped with a tissue paper and weighed (W_1). The percentage of water uptake was calculated by,

$$\% \text{ water uptake} = [(W_1 - W_0) / W_0] * 100$$

W_1 – weight of the sample after immersing in water

W_0 - initial weight of the sample

Oil absorption studies:

The procedure and formula which was followed in 3.2 for water absorption studies was also followed for oil absorption studies. But oil was used instead of water for soaking of the sample.

Morphological analysis:

Morphological studies of the developed mango seed shell plates were done using scanning electron microscope (SEM), with the accelerating voltage of 7 kV and magnification of 500 x. The samples were coated with a gold layer before the analysis, to improve their electric conductivity.

RESULTS AND DISCUSSION

FTIR Analysis:

FTIR result was interpreted using, 'Origin 6.0' software and graph was plotted. FTIR spectra of the samples are shown in the fig. 3. The peaks observed at 0%, 10 %, 20 %, 30 % and 40 % don't have large differences. Natural fibers mainly consist of cellulose, hemicelluloses and lignin, and thus the FTIR spectra obtained also possess these components only. The most commonly found chemical bond in the sample are C-O, C-H and C=O. Three main peaks were obtained at all the samples. The first peak observed around 1008.06 cm^{-1} is associated to C-O ester carbonyl stretching in the cellulose, lignin and their glycosidic linkages. The peak detected at 1745.35 cm^{-1} and 2929.13 cm^{-1} are associated with C=O stretching[6] and C-H stretching[11], due to the presence of waxes in mango seed shell.

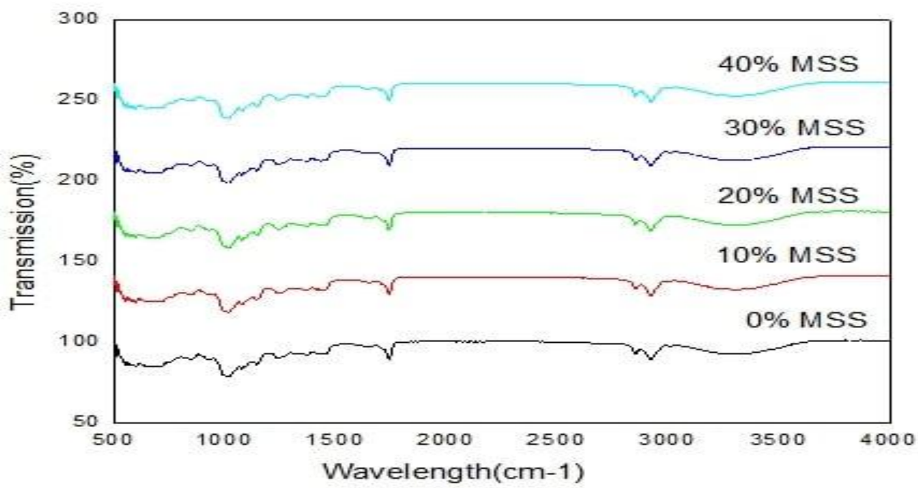
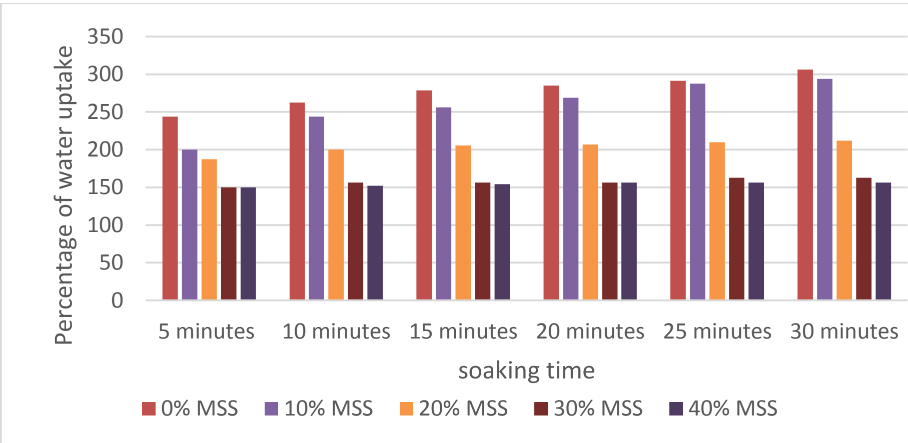


Fig. 3: FTIR Chart

Water absorption studies:

From the values obtained (Fig.4), it is inferred that the samples followed Fick's law of diffusion. According to this theory, the absorption of water occurs quickly at the beginning of the soaking process, whereas the water absorption gets slows down as soaking time increases. Due to the presence of the filler material like bagasse powder, mango seed shell powder and rice husk powder forms an obstacle and prevents the uptake of water. The obtained property is desirable in case of commercialization of the developed products.

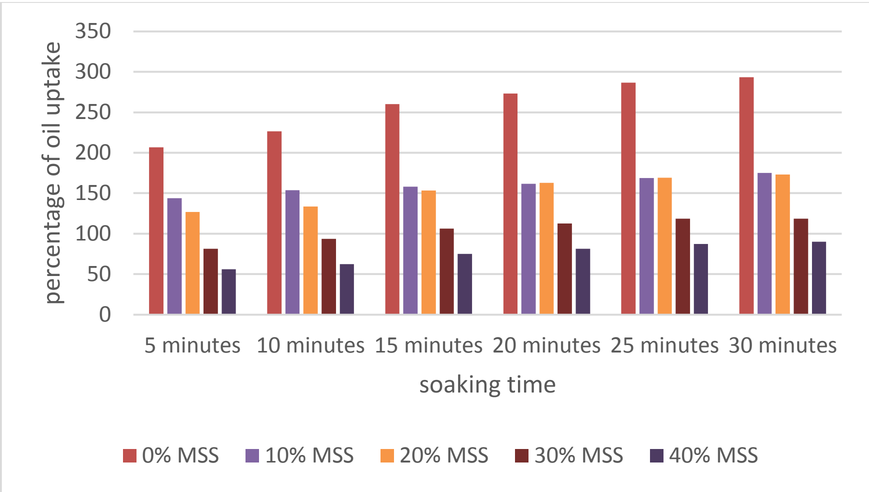
Fig. 4: Percentage water uptake of the sample



Oil absorption studies:

Since food materials possess oil content in it, oil absorption studies must be done to analyse the time taken to absorb the oil. The percentage of oil uptake was increasing as the fiber content increases. The initial percentage of oil uptake, is more when compared to the percentage of water uptake, it can be inferred from the fig.5, that the samples absorb oil faster than that of water. Sample containing 30 % and 40 % by weight of mango seed shell are considered as the best to withstand the oil present in food, since the oil uptake percentage is 118.7 % and 90 % even at a soaking time of 30 minutes.

Fig. 5: percentage oil uptake of the sample



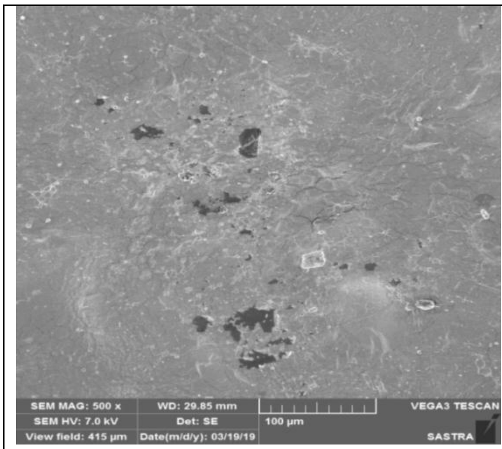


Fig.6. 0 % mango seed shell

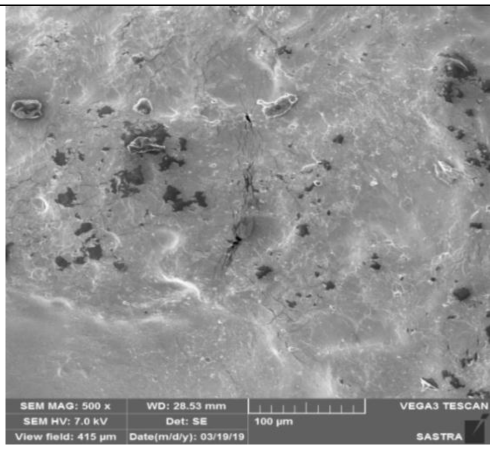


Fig.7. 10 % mango seed shell

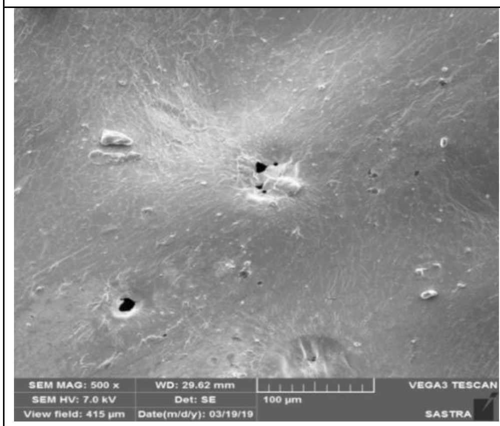


Fig.8. 20 % mango seed shell

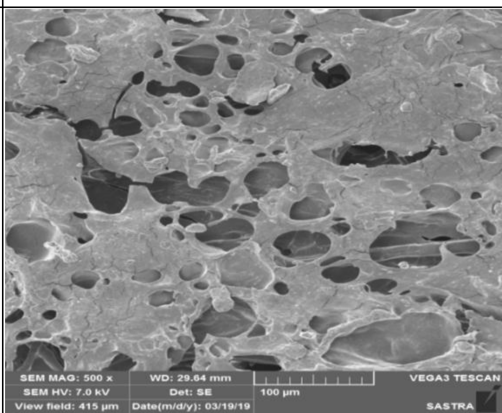


Fig.9. 30 % mango seed shell

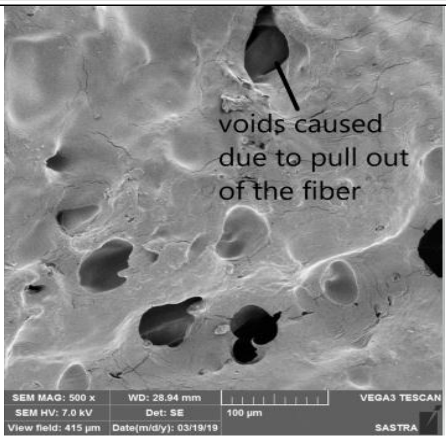


Fig.10. 40 % mango seed shell

CONCLUSION

The mango seed shell is considered as an underutilized by-product of mango. By using this in the development of biodegradable tableware it is possible to control the wastes which fills the land and water and it also acts as a better alternative for single use plastic cutleries. The best biodegradable tableware was obtained when 30 % of mango seed shell by weight, 20 % corn flour, 10 % wheat flour, 3 % rice husk powder, 2 % sugarcane bagasse powder, 10 % waste paper pulp and 25% of corn starch was used. In case of 40 % mango seed shell by weight, due to more fiber loading, moulding of the sample was difficult.

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