Experiments on Production of Bio-composite Plates from Pistachio Shells, Date Pits and HDPE

A. Ghazanfari
Department of Agricultural Machinery
Shahid Bahonar University
Kerman, Iran

S. Panigrahi  L. Tabil Jr.
Department of Agricultural and Bisresource Engineering
University of Saskatchewan
Saskatoon, Saskatchewan

Written for presentation at the CSAE/SCGR 2005 Meeting
Winnipeg, Manitoba
June 26 - 29, 2005

Abstract

Biocomposite plates were prepared by combining 20% of ground date pits or 20% pistachio shells with high density polyethylene. The plates were made through compression molding process at 180° C with a maximum pressure of 20 kPa. In general both material showed a good potential to be used as a filler in production of biocomposites. However, plates made from date pits had a better appearance and higher melt flow index. The dispersion and bounding of the date pit powders were superior to those of pistachio shells. Plates made from pistachio shell had a better stiffness than the plates made from date pits. Adding 1% flax fiber to the date pits mixture enhanced the stiffness of the resulting plates.
Experiments on Production of Biocomposite Plates from Pistachio Shells, Date Pits and HDPE

Introduction

Iran is the largest producer of pistachio and dates in the world. The production of date is about 900,000 metric tons and the production of pistachio nuts is about 210,000 MT (Iranian Ministry of Agriculture, 2002). Date pits form part of the integral date fruit in the order of, depending on variety and quality grade, 6-12% of its total weight. Date pits become available in concentrated quantities when pitted dates are produced in packing plants or in industrial date processing plants where dates are processed for sugar, vinegar, alcohol or other products. The whole or ground pits are used as an animal feed which apart from the value of the protein and fat is favored by the rather high hemicelluloses content. Dates pits contain 7-10% oil and about 20% crude fiber. The oil extracted from date pits is pale yellowish-green with a pleasant odor and it has cosmetic and industrial application. On the other hand, pistachio shell is also become available as a by product in pistachio processing plants. The shell is woody and has no nutrient value. It is often used as elementary fuel for heating or buried to decompose and to be used as soil fertilizer.

To utilize these abundant natural solid by-products industries are seeking new opportunities. The cosmetics industry has adopted the use of agro-shell grits and flours in the manufacture of high quality facial scrubs, soaps, and creams. The use of agro-shells for soft grit blasting is increasing. These soft grit materials are particularly effective where the surface of the metal under its coat of dirt, grease, scale, carbon, etc. Agro-shell grits and flour have very low densities and are currently being used as filler in rubber, plywood industries.

In many industrial, structural and household supplies polymer based materials are playing an important rule (Wang et al. 2003). However these materials lack sufficient stiffness band are highly susceptible to creep, especially at elevated temperatures. One way to improve these properties is to combine the polymer matrix with filler or a reinforcing fiber (Wielage et al., 2003). The resulting materials are called composite which poses enhanced physical and mechanical properties. Traditionally synthetic fibers
have been used for reinforcing the polymer based products. However, agro-fibers, such as flax fiber, have distinct advantages such as low cost, light weight, and resistance to damage during processing over the synthetic fibers (Burgueno et al. 2005). A problem frequently encountered in preparing composites from wood fiber are inadequate fiber dispersion and fiber bonding between fiber and polymer matrix, moisture absorption by natural fibers, and non-uniform mechanical and physical properties of natural fibers (Kolybaba et al, 2003).

As pistachio shells and date pits are abundant as by products in processing plants, we are considering utilizing these bio-products as a filler and reinforced material for bio-composite production. The objectives of this research were: to use pistachio nuts, and date pits in conjunction with high density polyethylene for production of bio-composite plates through compression molding and to compare and assess some mechanical and physical characteristic of the resulting bio-composites.

**Material and Methods**

The pistachio shells and the date pits were supplied by local producers in Kerman, Iran. The shells and the pits were cleaned and washed and then were oven dried at 75°C for 24 hours. The shells and the pits were then ground to pass a 1mm screen sieve. The ground materials were then truly mixed with HDPE and flax fiber with the following proportions:

- **Treatment 1**: 80% HDPE  20% Pistachio shells  0% flax fiber
- **Treatment 2**: 79% HDPE  20% Pistachio shells  1% flax fiber
- **Treatment 3**: 80% HDPE  20% Date pits  0% flax fiber
- **Treatment 4**: 79% HDPE  20% Date pits  1% flax fiber

The mixtures, 300 g each, were separately placed in the mold of a hydraulic press and compressed at a maximum of 20 MPa and 180°C. The mold of the hydraulic press (Princess Auto Ltd. Winnipeg, MB) had a lower female die and an upper male die, which are pressed against each other to form samples plate. The diameter of the tray bottoms is
147 mm, and both dies contain heating elements. After making each plate sample, the plate was removed and cooled at room temperature.

The stiffness properties of the plates were measured using the “Procedure B” as described by ASTM Designation: D790-97 (ASTM, 1998). Test specimens with the dimensions of 126 mm x 28 mm were cut from each sample and placed on a three point bend assembly as described by the ASTM designation. The three point loading assembly was mounted on a testing machine (Instron Model 1011, Instron Corp., Canton, MA). A 5 kN load cell was used to apply pressure at a rate of 1 mm/minute to the specimens.

In these experiments melt flow index of each treatment material was determined using the ASTM Designation D: 1238-86. Melt flow index is a number that specifies the amount of plastic/composite material extruded under a specified constant pressure and at specified temperature. The Melt Flow Index determines the processability of a material during different types of molding processes. The machine used in these tests was a melt flow index meter (Model MP 993, Controller/Time, Tinius Olsen, PA, USA). To measure the melt flow index, the cylinder of the meter was filled with the sample raw material. The sample was heated for 5 minutes at 180°C. Then the melted sample was allowed to flow out under a constant load of 2160 g for 10 minutes. The weight of the material that flowed out within ten minutes was used as the melt flow index for each treatment.

Thin layer samples with a dimension of about were cut from each plate. The pictures of the cut samples were taken by a scanning electron microscope (SEM) at 75 magnification level. Then after examining the pictures, the pictures of critical areas within each picture were taken with a magnification level of 300. The pictures were visually inspected for assessing the dispersion of the agro-based material within the polyethylene matrix and for bonding between these materials.

**Results and Discussion**

The ground pistachio shell were in general small, dry, hard and pale yellowish pieces while the ground date pits were oily and brownish powders. The difference in the appearance of the material was due to their original composition. As was mentioned the date pits contain significant amount of nutrient in compare with pistachio shell which
lacks any nutrient value. Mixing of the date pits was done better than mixing of pistachio shell due to the cohesive property of the ground date pits.

Two typical pictures of the plates made, one for date pits and one for pistachio shells, are presented in Figure 2 and 3, respectively. The date pit plates exhibited a red brownish color while the pistachio shell plates pale brown. Visual examination of the plates revealed that the dispersion of the ground date pits was better than the dispersion of the pistachio shells within the matrix. However the date pit plates retained the odor of the date pits during compression molding and to some extent after they were produced. In general both type of plates had a good appearance.

![Fig. 2. A typical picture of the biocomposite plates made from date pits.](image)
The results of melt flow index for the four treatments are 0.38, 0.36, 0.55 and 0.48 g/min, respectively. The melt flow index of the date pit mixtures is higher than those of the pistachio shell mixtures, which is mainly due the existence of oil and nutrient in the date pits. It was mentioned earlier, date pits contain about 10% oil which contributes to better flow of the mixture when heated. Adding 1% of flax fiber to each mixture of pistachio shells or date pits resulted in a slight decrease in melt flow index of both mixtures.

The results of mechanical test for the mean values of the stiffness of the four treatments are 294, 268, 233, 214 kPa, respectively. The stiffness data are based on five samples tested for each treatment. There was a considerably amount of variations within the data. However based on the average results, in general the plats made from pistachio shells had higher degree of stiffness than those made from date pits. Adding 1% flax fiber to the treatment mixtures slightly improved the toughness of the date pit plates, while it slightly decreased the stiffness of the pistachio shell plates.

Two typical SEM pictures of the samples cut from the plates in Figure 2 for date pits and in Figure 3 for pistachio shells. Both pictures have a magnification level of 75. The picture indicates a relatively good dispersion of the ground date pits within the matrix. The bounding of the date pit particles with polymer is also relatively good, since no big gap is visible in the picture. On the other hand, as shown in Figure 5, the pistachio shell
pieces are not uniformly dispersed within the matrix and the bonding between them is not as good as those for date pits. The low bonding is clearly visible at the lower left edge of the shell piece in Figure 5.

Fig. 4. A typical SEM picture made from cut samples of date pit plates

Fig. 4. A typical SEM picture made from cut samples of pistachio shell plates.
Summary and Conclusions

Composite materials are playing an important role in various industrial sectors. These materials generally lack mechanical strength which can be enhanced using synthetic or natural fibers as a reinforcing material. On the other hand agro-based material can also be used as filler in composite material to reduce the final cost and improve their environmental degradability.

In this study pistachio shells and date pits were used as filler for making biocomposite plates in conjunction with polyethylene. Both of these agro-materials are produced in large amount as waste products of pistachio or date processing plants.

Plates made in these experiments contained 20% by weight either ground pistachio shells or date pits. In similar treatments, 1% flax fiber was also used as a reinforcing material. The results indicated that, in general, the date pit plates had a better appearance, melt flow index, dispersion and bonding. But lower stiffness than pistachio shell based plates. The stiffness of the date pit plates improved by adding 1% flax fiber as a reinforcing agent. Thus date pits has a good potential to be used for producing biocomposite material, however more research is needed to determine the exact proportion of each material within the biocomposite mixture. Special attention should be made to eliminate the odor from the final products.

Acknowledgement

The help of the undergraduate students: S. Alavi, S. Ebrahimi, B. Majdzadeh and S. Eshaghipour from Shahid Bahonar University, Kerman Iran for initiation of this project is acknowledged.

References


