# INVESTIGATE THE CAPABILITY USE OF SOYBEAN STALK IN MANUFACTURING NATURAL FIBERS/THERMOPLASTICS COMPOSITES

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## Abstract

*The use of renewable and natural fibers instead of synthetic fibers, as reinforcement additives in thermoplastics, due to environmental friendly, low costs, etc are growing. However the present paper is concerned with the physical and mechanical properties (Flexural resistance, tensile, impacted absorbed energy, water uptake and thickness swelling) of Soy Stalk Flour/Polyethylene composite. Various composites using of different percentage of Polyethylene (PE) and Soy Stalk Flour (SSF), 50/50 and 60/40 by weight, have been made, and their mechanical and physical properties are measured. The statistical analysis of result shows that, the best mechanical properties (includes flexural, tensile, notch and unnotched absorbed impact energy) were obtained when we used the 60/40 mixture ratio of soy stalk flour and HDPE, and 4% MAPE. But the best physical properties (includes water uptake and thickness swelling) related to 50/50 mixture ratio of HDPE and soy stalk flour, and 4% MAPE.*

*In summary, the results revealed that soy stalk can be used as reinforcement additives in thermoplastics conforming to the standards (ASTM standard).*

## Introduction

One of the most important problems in wood industries in Iran is serious shortage of wood resources. On the other hand, new research in field of use of agriculture residues fiber such as wheat straw, corn stalk, bamboo, bagasse, etc (3,4,9,10,11 and 12) and other agriculture residues have shown that use of these fibers as raw material in wood industries are possible. Therefore, one of the potential alternatives instead of wood in composite manufacturing is agriculture residues. Soy stalk is one of these residues. Soy stalk production, in Iran, is more than 311000 Tons annually (7). The chemical composition of soy stalk was investigated that is made of cellulose, Hemicelluloses and lignin, but its strength in compare with wood is lower (2). In Iran, the most utilization of these materials is animal bedding; animal feeding or they have burnt. With turning utilization of these materials in composite manufacturing, we can turn a valueless waste into valuable material for composite production.

Within last few years, there are a growing interest in wood or other lignocellulosic fibers/plastic composites [2], because of the good performance in application of many

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building material such as fencing, decking, railing, dock, indoor furniture [1], automotive paneling [5], windows and door profiles [8] and etc. wood/plastic composites (WPCs) were often manufactured using of pressing, extrusion or injection molding, that wood particles dispersed as filler into a thermoplastic matrix. The most popular wood flour size that use in WPCs production is from 20-100 mesh [8, 6]. The thermoplastic monomers were frequently used for WPCs including polypropylene (PP), polyethylene (PE), polystyrene (PS) and polyvinyl chloride (PVC).

Wood or agriculture residue fibers are hydrophilic while thermoplastic monomers are hydrophobic. Therefore, they are incompatible in thermodynamics, which results in weak adhesion between wood fiber and thermoplastic monomers, and finally poor ability to transfer stress from thermoplastic matrix to wood fibers. Thus, in order to improve the compatibility, we should be used coupling agents. Several studies have been made to investigate the possibility of natural fibers as reinforcement in thermoplastics . The results have shown that natural fibers have potential to be used as reinforcement in thermoplastics. Panthapulakkal et al. [9,10] with the comparison of mechanical properties of the wheat straw filled PP with that of the wood flour and old newsprint filled PP showed the suitability of wheat straw as alternative filler for thermoplastics. Oksman [8] reported that natural fiber reinforced thermoplastics (NRT) have a high stiffness compared to pure polymer and better stiffness than the glass fiber reinforced thermoplastic (GRT) while, GRT composite have superior strength and impact energy properties compared to the NRT composites.

Fuentes Talavera et al. [12] inWPC producing of bagasse showed that when press time and press temperature are increasing, the bending strength (MOR) and bending modulus of elasticity (MOE) increase and water uptake and thickness swelling reduced, while an increase in pressure had a negative effect on bending strength and MOE.

The objective of this study was to investigate the effect of soy stalk flour amount and it's geometry on the physical and mechanical properties of soy stalk flour/PE composite.

## Material and Methodology

*Material*

High Density Polyethylene (MFI:20 dg/min and Density: 0.956 *gr/cm3*) was provided by arak petrochemical company, Iran. Soy stalks as reinforcement agent supplied by local farmers in Golestan province, Iran. Maleic anhydrate grafted polyethylene was purchased from Kimia Javid Sepahan Ltd Co.

*Methods*

*Preparation of soy stalk flour*

The soy stalks were manually cleaned to remove leaves and other waste material. The cleaned soy stalks were cutted to pieces small enough to feed into the chipping machine and chipped using of Pallman chipper. Then, they were milled by a laboratory mill using a mesh size of 2 mm. The Particles that pass through the sieve 40 and 60 mesh were selected and were dried at 105˚C for 24 hours to the moisture content below 1% before the extrusion process.

*Composite manufacturing*

The dried soy stalk flour in two type of particle size (40, 60 mesh) and HDPE blends (60 mass% soy stalk flour with 40 mass% HDPE, 50 mass% soy stalk flour with 50 mass% HDPE and 40 mass% soy stalk flour and 60 mass% HDPE) and also 3% MAPE based on dried weight of HDPE and soy stalk flour were compounded in a co-rotating twin screw extruder that temperature range was of 150- 160˚C for different zone and speed of screw was190 Rpm. Then, the produced composites were cutted into granulates using of laboratory granulator and finally they were injection molded (the injection conditions include injection temperature: 180 ˚C; injection pressure: 100 $kg/m^2$ and injection time: 10 S).

*Physical and Mechanical tests*

Mechanical tests including Flexural, Tensile, notched and unnotched Impact tests were performed accordance with ASTM standards. The mechanical properties carried out on an instron testing machine. A crosshead speed of 5 mm/min was used when samples were tested. The impact properties were measured by using a santam impact tester. Also physical properties (water absorption and thickness swelling) were determined according to ASTM Standards. The measurements were performed at a temperature of 25˚C and a relative humidity of 50%.

*Result and discussion*

*Mechanical properties*

The results are shown in Fig. 1 to fig. 3 and demonstrate the influences of amount of soy stalk particles on the mechanical properties of soy stalk/PE panels. As it can be seen in the fig. 1, the produced panels with 60% soy stalk exhibit higher mechanical properties than panels made with 50% soy stalk. The average tensional MOR and MOE values increase from 27.31 to 28.94 MPa and from 3918 to 4976.83 MPa, respectively. These differences were significant statistically.

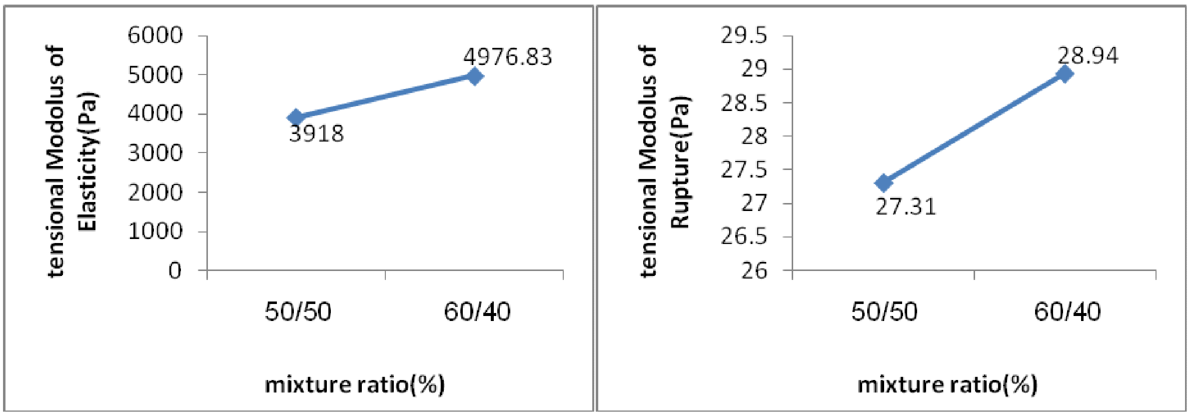


Figure 1. Average values of tensile MOR and MOE of panels

The same trend was observed in flexural MOR and MOE values. As it can be seen in the fig. 2, the produced panels with 60% soy stalk exhibit higher mechanical properties than panels made with 50% soy stalk. The average flexural MOR and MOE values increase from 47.06 to 47.79 MPa and from 2963.67 to 3636 MPa, respectively. These differences were significant statistically.

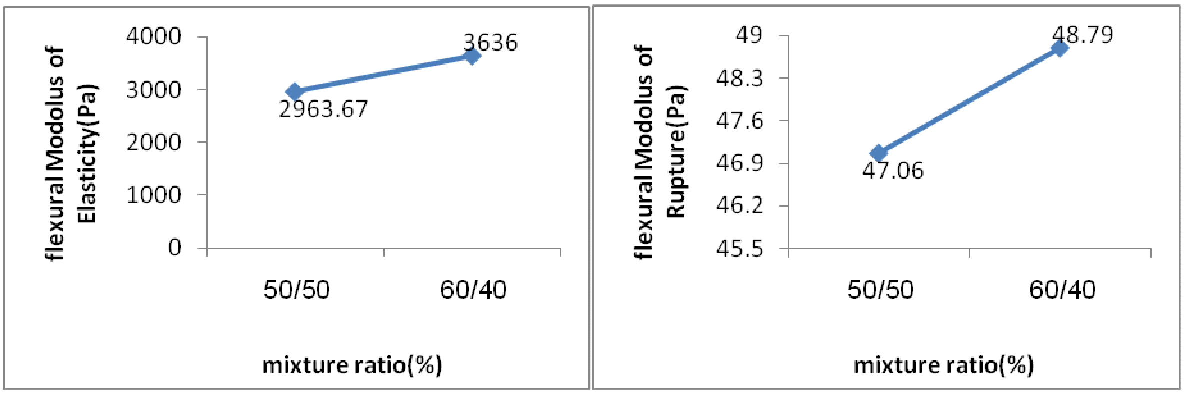


Figure 2. Average values of flexural MOR and MOE of panels

In contrast to tensional and flexural MOR and MOE, Impact absorbed energy value decreased with increase amount of soy stalk particles from 40 to 60%. As it can be seen in the fig. 2, with increase of soy stalk particles from 40 to 60%, the average values decrease from 0.52 to 0.27 J. This difference was significant statistically.

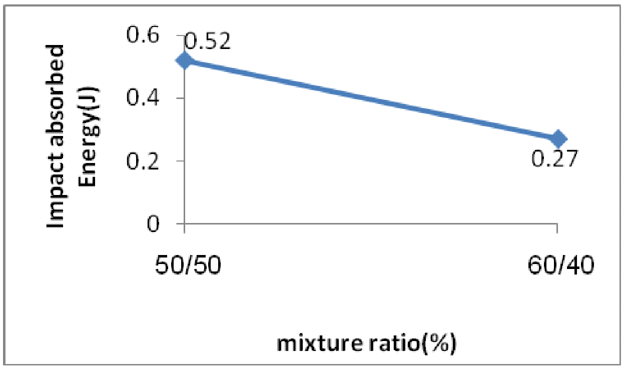


Figure 3. Average values of Impact absorbed energy of panels

*Physical properties*

The results are shown in Fig. 4 and demonstrate the influences of amount of soy stalk particles on the physical properties of soy stalk/PE panels. As it can be seen in the fig. 4, the produced panels with 50% soy stalk exhibit better physical properties than panels made with 60% soy stalk. The average water absorption and thickness swelling values increase from 12.44 to 13.8 and from 6.45 to 6.69, respectively. These differences were significant statistically.

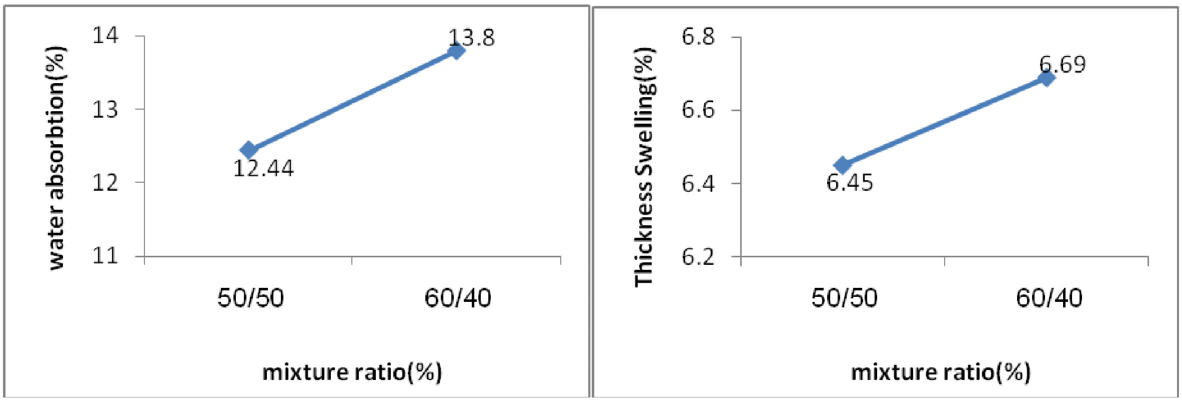


Figure 3. Average values of Impact absorbed energy of panels

*Conclusions*

According to the test results, all mechanical properties of the panels, except impact absorbed energy property, were improved when the amount of soy stalk particles was increased from 50 to 60%. The best mechanical properties (includes flexural, tensile, notch and unnotched absorbed impact energy) were obtained when we used the 60/40 mixture ratio of soy stalk flour and HDPE, and 4% MAPE. But the best physical properties (includes water uptake and thickness swelling) related to 50/50 mixture ratio of HDPE and soy stalk flour, and 4% MAPE.

In summary, the results revealed that soy stalk can be used as reinforcement additives in thermoplastics conforming to the standards (ASTM standard).

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