Improving the Mechanical, Water Vapor Permeability, Antimicrobial properties of Corn-Starch /Poly Vinyl Alcoholic film (PVA): Effect of Rice husk fiber (RH) & Alovera gel (AV)

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Abstract: Essentially because of ecological points, petroleum-based plastics are being supplanted by natural polymers. In the most recent decades, the starch idea is outstanding as a green material. Because of the developing interest for starch biodegradable materials and the film-forming capacity it has been significantly utilized in the food packaging area. Polyvinyl alcohol (PVA) is one of the synthetic biodegradable materials that has the upsides of good film formation and high thermal stability. It has been utilized as coatings, packaging material, and in drug delivery applications. Aloe vera (AV) gel, an individual is a promising material in food preservation and has great antimicrobial and anti-inflammatory properties. Because of its film-forming capacity, it has been utilized in the edible film and coatings. Natural fibers from agricultural waste are finding their significance in the food packaging sector because of the numerous favourable circumstances, for example, their lightness, minimal effort and being earth amicable. The rice husk (RH) is acquired from agro-industrial waste, can be utilized as filler in different bio composites materials. Themain purpose of this examination was to investigate the impact of Rice husk fiber and Alovera gel on the Mechanical, Water Vapor Permeability, Antimicrobial properties of Corn-Starch based film.

1. Introduction
Extensive ecological awareness has prompted the formation of various biopolymers in ecological materials capable of supplanting petroleum-based synthetic materials in the packaging sectors. As one of the biodegradable polymers, starch has become a promising applicant attributable to its accessible as carbohydrate assets from sustainable stock feeds in grains and tubers, edible, nontoxic biopolymers, nonpolluting, low cost and thermoplastic biopolymer[1]. It has the superb film-forming ability yet its application is incredibly influenced by the intrinsic hydrophilicity and non-resistance from microorganisms[2]. PVA is a biocompatible, water-soluble polymer, which is a sort of thin-film material with fantastic packaging performance and high thermal stability[3]. Be that as it may, It has
low dimensional stability because of high moisture absorption. Moreover, it has a reasonably huge cost appeared differently in relation to other commercial polymers. Therefore, mixed with renewable and abundant agro-active ingredients, for example, polysaccharides, in particular starch, can be used to reduce cost. [4]. Mixing with starch produced greater resistance to moisture and accelerated degradation. Aloe vera is a stemless cactus-like plant that has a place with the Liliaceae family [5]. The restorative employments of the gel juice (orally) are against blockage, skin illnesses, and cardiovascular issues [6]. As of late other significant property of Aloe vera has been accounted for, for example, mitigating and anti-infection activities. It has antibacterial property against gram-positive and gram-negative bacteria [7]. Aloe vera can be applied as consumable coatings for organic products as its biological activities prevent loss of moisture, control respiration rate and reduce microorganism production. In present investigation effect of AV antimicrobial properties on Starch/PVA biocomposite was studied and observed that by increasing concentration of AV antimicrobial properties of Starch/PVA biocomposite film was increased. The composite based on natural fibers has various tremendous points of interest over composites with engineered fibers, for instance, ease, lighter weight, available as plants or waste, is not toxic, and doesn't cause skin irritations [8]. The comfort of these composites lies in the manner that the ingredients are gained viably from normal or agricultural waste and consequently the composites can be made generally effectively. In this investigation RH utilized as natural fiber. During rice processing rice husk is produced as a by product and around 18.3 million tons of rice husk is produced each year. It was seen that increase of rice husk concentration as filler caused improvement in mechanical properties but decreased water vapor permeability.

2. Experimental

2.1 Materials

The starch that was utilized in the preparation of the film was corn starch and was acquired from the local market. Polyvinyl Alcohol (PVA, Mol.weight 1,20,000) was purchased from Acrylamide India. Glycerol (Mol.weight 92.09) was purchased from Estelle Chemicals, Maharashtra, India. Rice Husk was obtained from a neighbourhood rice factory for reinforcement in Starch/PVA biocomposites at an ostensible price, Maharashtra, India. Completely developed aloe vera leaves were gathered from a solitary nursery plant.

2.2 Preparation Methods

Two biocomposite films were prepared. Such as husk reinforced Starch/PVA bio composite and AV gel based Starch/PVA bio composite.

2.2.1 Preparation of Starch/PVA/RH biocomposite

The Starch/Polyvinyl alcohol/Rice husk biocomposite for food packaging film was prepared with the solvent casting method. In this method, the film solution was prepared by mixing (40/60) composition of Starch/PVA in distilled water to form a homogenous gel solution. The blend was persistently mixed using an electric stirrer for around 40 min at 90°C. Then the plasticizers, for example Glycerol (0.1%) and cross linking agent Citric acid (20%) were added to the above blend. We have included Rice husk fiber for the reinforcement of the material. To expel the impurities from the fibers, they were washed with a mild detergent required during the extraction of fibers. The fibers were dried in a hot air oven maintained at 40°C for 12 h. Subsequent to drying the fibers were granulated to change over into fine particles. These particles of different concentration (10%, 20%, 30%, 40%) have been added to the previous matrix. The suspension in this way formed was placed on a Teflon plate to prepare the biocomposite film. The biocomposite film was dried at room temperature for 72 h.
2.2.2 Preparation of Starch/PVA/AV biocomposite

Develop fresh leaves of Aloe Vera were washed with water. At that point, their thick epidermis was evacuated and the strong mucilaginous gel was gathered in a sterile container. Gel of various concentration (10%, 20%, 30%, 40%) was blended in with (40/60) composition of Starch/PVA. The development of Starch/PVA suspension was depicted above. In a similar route here Starch/PVA suspension was additionally framed. The prepared suspension was poured onto a Teflon plate to form the biocomposite film. The biocomposite film was dried at room temperature for 24 h.

2.3. Mechanical properties of Rice husk(RH) fibre reinforced St/PVA biocomposite film.

The tensile strength (TS) and percentage of elongation (%E) of the St/PVA bicomposite film with RH fiber as reinforcing material were performed with the computerized Universal Testing Machine based on the ASTMD638 standard. The average sample thickness was around 1 mm and was operated at a cross-head speed of 20 mm/min at 30°C. The test was performed with five samples and averaged.

2.4. Water vapor Permeability of Rice husk(RH) fibre reinforced St/PVA biocomposite film.

The water vapor transmission rate (WVTR) of the Starch/PVA/RH biocomposite films with a surface of 50 cm², was determined with a water vapor permeation meter according to ISO 15106-1 test method. The WVTR was determined at 35°C and 90% relative humidity. As the water solubilized the membrane and penetrated through the sample films, the nitrogen gas swept and transported the water vapor molecules into a calibrated infrared sensor.

2.5. Antimicrobial activity of Alovera gel based St/PVA biocomposite film.

The Antimicrobial activities of Starch/PVA/AV films dependent on various concentration of AV(10%, 20%, 30%, 40%) against E.coli and Klebsilla pneumoniae utilized as model of Gram-negative bacteria and Bacillus cereus as a Gram-positive model. The antimicrobial activity was performed using the disc diffusion method, the Starch/PVA/AV biocomposites were cut into circles with a diameter of 1.5 cm, sterilized in an autoclave for 20 min at 130°C, and were put on a surface of supplement agar media previously incubated by bacterial suspensions target of E.coli, Klebsilla pneumoniae and Bacillus cereus, and afterward incubated for 27 h at 40°C and evaluated the inhibition zones.

3. Results & Discussions

3.1. Mechanical strength

The outcomes acquired on rice husk reinforced Starch/PVA/RH biocomposite at various weight percentage for example 10wt. %, 20wt. %, 30wt. % and 20wt. % indicated that the mechanical properties improved with the addition of fiber weight percentage.
The tensile strength and elongation at break of Starch/PVA/RH biocomposite are shown in figure 1. With an increase in the Rice husk fiber content, the tensile strength of the Starch/PVA/RH biocomposite film increased. The tensile strength of biocomposite film increased from 30.68 Mpa to 40.39 Mpa with the increase in the concentration of Rice husk fiber. The mechanical impact of Rice husk fiber on Starch/PVA bio composite film was remarkable. This outcome recommends that Rice husk fiber was all around dispersed in to the starch/PVA matrix. Furthermore, there was a strong interface between the Starch/PVA matrix and the Rice husk fiber, which permitted appropriate stress among matrix and fiber, bringing about the increase of tensile strength [9]. The elongation at break arrived at a maximum value of 300.02% with a fiber content of 40%. With the increase in the concentration of Rice husk fiber, the elongation at break of the biocomposite film has increased from 150.03% to 300.02%, which could be due to the great compatibility between the Rice husk fiber and Starch/PVA matrix. The presence of the – OH group in the Rice husk fiber and its hydrophilic nature are compatible with Starch/PVA. Another resonance due to a greater elongation in Starch/PVA/RH biocomposite due to the increase in the crystalinity of the cellulose present in Rice husk fiber.

3.2. Water Vapor Permeability

Figure 2 showing the water vapor permeability of the starch/PVA/RH biocomposite with respect to different concentration of Rice husk fiber after conditioning at room temperature.
As indicated by the findings appeared above, the water vapor transmission rate of Starch/PVA/RH biocomposite with various Rice husk concentrations has increased from 6.44 g.mm/day.m² to 12.6 g.mm/day.m². As per the above information, the water vapor transmission rate expanded with the increment of Rice husk fiber weight fraction from 0 to 40%. It has been reported that fibers, for example, rice husk, kenaf, and wood compare an excessive amount of more water absorption when the fiber loading is expanded therefore water vapor permeability additionally expanded [10,11]. The water absorbing property of rice husk causes an increment of water vapor permeability in biocomposites. In general, the biocomposites reinforced with natural fiber show enormous water vapor permeability because of the presence of micro voids at the interface of reinforcement/matrix.

3.3. Antimicrobial assessment

In the present examination, the antibacterial activity of the biocomposite film of Starch/PVA based on Alovera gel at various concentrations against Gram positive bacteria and Gram negative bacteria was assessed with the disc diffusion technique. The four concentrations of Alovera gel-based Starch/PVA biocomposite was examined in the present examination showed differing level of inhibitory effect against the chosen bacterial pathogens as shown in figure 3(a),(b),(c). The chosen microorganisms present a significant hazard to human health [12]. They were utilized to test the antimicrobial activity of the examined biocomposite films. *S. aureus* was an significant food adulterant that produces bacterial contagion. *E. coli, Klebsilla pneumonia and Bacillus cereus* were used to evaluate the antibacterial activity of the prepared biocomposite films.
The present examination demonstrated the anti-bacterial property of the Starch/PVA biocomposites based on Alovera gel against the chosen strains of human pathogenic bacteria, the level of inhibition varied according to the concentration of the alovera extract. Highest concentration of Alovera gel based Starch/PVA biocomposites showed most extreme zone of inhibition. The antibacterial activity of the Alovera gel based Starch/PVA biocomposites was seen as progressively compelling as indicated by the increase of Alovera concentration in Starch/PVA biocomposite. This could be ascribed to presence of more amount of the anthraquinones and phenolic antioxidants in the Alovera gel [13].

4. Conclusion
In this investigation, it was discovered that the content of RH fiber influenced the structural integrity, tensile strength and water vapor permeability of the biocomposites. According to the observation, the increase in the quantity of rice husk in the Starch/PVA biocomposite has led to an increase in tensile values. The water vapor permeability of the Starch/PVA biocomposite filled with RH was estimated.
and it was seen that 40 wt. % rice husk has a higher water vapor transmission rate. Rice husk with a minimum content should be considered an alternative additive to diminish the water vapor transmission rate. The antimicrobial activity of Alovera gel-based Starch/PVA biocomposite film against *E. coli*, *Klebsilla pneumonia* and *Bacillus cereus* were assessed. It came about that bacterial inhibition increases with the increase of Alovera gel concentration in Starch/PVA biocomposite film. These characteristics make the biocomposite a polymer in perspective for food packaging applications.

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