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Research Article

Waste Coir Nanofiller Fused Gallus-Gallus Fibres Reinforced PMC

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This research aims to increase the utility of globally and abundantly available waste natural fibres of Gallus-Gallus fibres coir waste from mattress and car seat manufacturing factories. The composite samples were prepared with a rally round of polyester resin of grade GP500 bio-epoxy by synthesizing specially treated Gallus-Gallus fibres selectively used for reinforcement and characterizing them through static and dynamic mechanical analyses to identify their wide range of applicability. The Gallus-Gallus fibres are preprocessed with sodium oxidative and a half per cent of potassium manganate (VII) chemical solution. The selective use includes 5 mm, 10 mm, 15 mm, and 20 mm length of the Gallus-Gallus fibre, and the quantity of reinforcement was 10%, 20%, and 30%. Five alternate layers of matrix and fibres, with vertical and horizontal orientation, are considered; 12 different samples of Gallus-Gallus fibres reinforced polyester polymer composites and a neat polyester composites were synthesized and characterized for moisture absorbability, tensile strength, tensile modulus, flexural strength, flexural modulus, wear resistance, and outperformed composites were included in microscopic examination and dynamic Mmchanical analysis. The interesting results are the preferred resin, supported for good surface finish, interface bonding, and totally in the enhancement of Composite properties. The composites are strong in tension (760.89 MPa) and sufficiently flexible (flexural modulus 5441.32 MPa), absorbed less moisture (5.8 g), high wear-resistant (least weight loss upon abrasion with a value of 0.1989 g), secured good results in dynamic analysis, and ensured homogeneous distribution of fibres in the matrix through a scanning electron microscopy image. The composites CPPC10, CPPC11, and CPPC12 performed well but composite CPPC12 outperformed.

1. Introduction

Globally, the availability of chicken feathers increases day-by-day multiple times due to the consumption of chicken flush through the wide variety of palatable tasty food styles and huge in volume. It was estimated that the feather disposal is 5–10 per cent of the weight of the chicken. Chicken feathers (Gallus-Gallus) contain 91% keratin protein. They are electrically and thermally low conductive materials and enhanced mechanical properties as fillers [1]. Some of the interesting results found in literature especially in the valorisation of chicken fibres were used as reinforcement materials in synthesizing composites. The authors in [2] used TPU-polyether resin as matrix and waste keratin Gallus-Gallus fibres (GGFs) as reinforcement (0%, 30%, and 60%) in synthesizing polymer composite through solvent-casting-evaporation method and investigated thermomechanical properties by dynamic mechanical analysis. Uniform distribution of fibres is ensured through SEM image [3]. RSO-polyurethane composite is synthesized in rubber seed oil-based polyurethane resin employed as a matrix in synthesizing 5%, 10%, 15%, 20%, and 25% weight percentage of Gallus-Gallus particles reinforced composites by the casting method. These composites were characterized by the test of hardness, moisture absorption, density tensile, and impact strength. It was found that an increase in hardness and tensile strength was observed in reinforcement from 15% to 25% and a decrease in the density and impact strength [3, 4] used polypropylene resin matrix in composing 5, 10, 15, and 20 wt.% Gallus-Gallus fibres in powder form reinforced in the matrix [5]. It was found that the reinforcement enhanced flexural and tensile properties but not impact strength. SR green epoxy 56 resin is used to compose an average length of 26 mm Gallus-Gallus fibres reinforced 60%, 70%, and 80% of weight fraction. They were characterized by thermal and acoustic insulation properties. The study [6] used the cellulose of butyl methylimidazolium chloride resin to compose curtain of hair, Gallus-Gallus, and wool reinforced composites and found that the reinforcement improved the mechanical properties. Alkali-treated Gallus-Gallus fibres are used to improve the mechanical properties of the composite [6] in which natural rubber was employed as resin/matrix [7]. Polylactic acid resin-based Gallus-Gallus particle of weight fraction, 2%, 5%, 8%, and 10% reinforced composites, reported that Gallus-Gallus fibres enriched the thermal stability of CFF/PLA composite. The studies [8, 9] also used Gallus-Gallus fibre fillers as heat insulation in Winter clothes. The study [10] synthesized glass/epoxy/Gallus-Gallus fibre hybrid composite for printed circuit board application and found that the dielectric constant of the composites decreased with fibre contents and similar to printed circuit board property achieved. The study [11] brought into play of poly-methyl methacrylate resin matrix to blend keratin fibres of Gallus-Gallus reinforced composite which resulted that the sign of the augment of storage modulus offers elevated stability, as replicated in the modulus behaviour, and reduction of Tan delta peak is a sign of the physically powerful interface. Waste SiC is utilized as filler material for preparing epoxy glass fibre composite and investigated the machinability in abrasive water jet machining by [12]. They used Taguchi and grey relation analysis to optimize the machining parameters. The study [13] recommended the green filler material for synthesizing the glass fibre epoxy composite through the compression moulding technique in which the 0.6 wt.% reinforcement outperformed. The study of [14] investigated the effects of oxygen plasma treatment on polyethylene matrix and found that higher flexural strength of 25.87 MPa was observed by the novel treatment but tensile strength was slightly reduced from 18.2 MPa to 17.7 MPa. The study [15] used benzoyl chloride treatment for the natural fibres of ramie and kenaf fibres; they optimized the weight percentage of fibres with Taguchi-based grey relational analysis and further optimized by TOPSIS technique [16]. The novelty utilized TiO_2 filler in the polymer composited and improved the tribological properties and reported that 40 wt.% SP/5 wt.% TiO_2 composition recorded good results. The study [17] recommended sodium bicarbonate treatment for natural fibres like jute fibre composites and found that such treatment improved the machinability of drilling [18]. Banana fly ash/sisal/pineapple composites are introduced and the wear parameters are optimized by GRA, and it is reported that the addition of filler materials and hybrid fibres with the polymer matrix results in increased friction.

Novelty of this research utilizes the used-waste of coir from the car seat and used bed and sofa set as nanofiller in fabricating novel composite. This research gives more importance on bio degradation after use so it utilizes grade GP500 bio-epoxy polyester resin to compile a composite matrix with Gallus-Gallus fibres reinforcement. The preprocessing of Gallus-Gallus fibres and special chemical treatment to refine the quality of Gallus-Gallus fibres and enhancement of their strengths. Investigation on the influence of the length of Gallus-Gallus fibres used and quantity of fibres reinforced in layer fashion composites. The originality can be claimed in the chemical solution prepared for processing and preprocessing of Gallus-Gallus fibres, composite matrix, and classifications of specially treated selective Gallus-Gallus fibrereinforced polyester polymer composites and use of nanofillers.

2. Materials and Methods

The use of Gallus-Gallus fibres as reinforcing elements in synthesizing hybrid composites is focused in this research.

2.1. Constituents of Composite. The Gallus-Gallus fibres are employed as reinforcement elements and the polyester resin of grade general purpose 500 bio-epoxy as matrix materials. The considerable properties of the matrix material are its casted laminate possesses tensile and flexural strengths that are 57 N/mm^2 and 85 N/mm^2, respectively. Their tensile modulus and flexural modulus are 3150 N/mm^2 and 3250 N/mm^2, respectively. Low volumetric shrinkage 7-8% and specific gravity 1.22. The Gallus-Gallus fibre physical and chemical properties are moisture absorption 16–20 wt%. Aspect ratio that is length to diameter ratio between the 30 and 50. The specific gravity of Gallus-Gallus fibre is 0.7 to 1.2 and the nature of rapidly degrade in highly alkaline environment (where pH value is 12.4), oven dried fibre recorded tensile strength about 70 MPa and young's modus up to 50 GPa, 43 : 100 for hardener and resin ration in wt%. The fast harder was used. The used coir from the waste car seat, waste

Figure 1: Fresh Gallus-Gallus fibres and waste coir powders.

bed, and sofa was first separated. That coir fibres were put into Soxhlet device; acetone, toluene, and methylated spirit were added in the ratio of 1 : 4 : 1 to dewax coir for 4 hours to 5 hours. Then, those fibres were extracted and dried at 380 K. After that such coir fibres were grinded multiple times and fine nanopowder is obtained. The average particle size was measured with use of nano ZS model Malvern particle size analyzer. It was in the range of 850 nm to 975 nm. Its chemical properties are 27.41% cellulose, 42% lignin, 14.63% hemicellulose, and 10.16% pectin/wax. The ultimate tensile stress was 106 to 175 MN/m^2 and Elongation was permitted up to 47%. Though polyester resin 20% weaker than bond made by epoxy, more fragile, they are useful, create low stress, and less expensive. Polyester resins are found working well along with epoxy since they are adequate adhesive [19]. The unsaturated polyester resin with epoxy unutilized to fabricate E-SiO_2 nanocomposites and achieve the amazing results of Shore A hardness increased by 14.0%, elongation at break by 86.80%, flexural stress by 86.81%, flexural strength by 69.18%, and Young's modulus by 37.03% [20].

2.2. Pretreatment of Gallus-Gallus Fibres. The fresh Gallus-Gallus fibres of various lengths were collected from the butcher shop or slaughter house shown in Figure 1. Those feathers were washed with running water. The cleaning solution was prepared as the distilled water is mixed with heated SDS solids in the ratio of 40 : 1 and a total of 10 litres as suggested [21–23]. The feathers were fed in the washing machine to agitate for 30 to 45 minutes with 50°C heated sodium dodecyl sulphate (SDS) solution. The SDS is used for bacterial decontamination in the Gallus-Gallus fibre. Then, those feathers were washed and agitated with plain distilled water for 15 minutes. After rinsing the feathers, they dried in sunlight for a day.

2.3. Chemically Treating Gallus-Gallus Fibres. The chemical solution was composed of with weight fraction of 5% caustic soda (sodium hydroxide, NaOH), five per cent of potassium permanganate VII, and the remaining ninety per cent distilled water. NaOH is a mandatory compound with potassium permanganate VII for the permanganate ion to react for the purpose (dermatitis, fungal infections, and so on). Then, the cleaned feathers were soaked in the solution for 10 hours. After that, the Gallus-Gallus fibres were washed in distilled water. Then, the washed Gallus-Gallus fibres were dried in sunlight for 48 hours. Hence, the Gallus-Gallus fibres were treated for refinement.

2.4. Hybrid Composite Samples Preparation. The compression moulding type synthesizes method is preferred. The percentage of specially treated Gallus-Gallus fibres (including nanofiller) varied four three levels as 10%, 20%, and 30% against the variation of the polyester matrix. The length of the Gallus-Gallus fibres varied in four levels from 5 mm to 20 mm with the step of 5 mm. The neat polyester was also prepared to validate the influence of specially treated Gallus-Gallus fibres and their contribution to the composite matrix. The neat polyester acts as a control specimen that is a benchmark specimen. The detailed research design is presented in Table 1. The layer arrangements are polyester/Gallus-Gallus fibres/polyester/Gallus-Gallus fibres/polyester. Hence, out of five layers, the Gallus-Gallus fibres are placed in the second and fourth layers. The percentage of contribution in the composite matrix is divided equally (as per research design allocation) for obtaining uniformity. For example, 90% polyester and 10% fibre (specially treated Gallus-Gallus fibres 8% and nanofiller 2%) are used for CPPC1, CPPC4, CPPC7, and CPPC10. The composite laminates CPPC2, CPPC5, CPPC8, and CPPC11 consists of 16% specially treated Gallus-Gallus fibres and 4% nanofiller) and the composite laminates CPPC3, CPPC6, CPPC9, and CPPC12 consist of 24% specially treated Gallus-Gallus fibres and 6% nanofiller. In those composites, respective lengthen fibres and polyester resin are distributed in layers as 30%, 5%, 30%, 5%, and 30% for a layer of first, second, third, fourth, and fifth, respectively.

2.5. Synthesize of Composites. The research design of synthesizing of proposed specially treated selective Gallus-Gallus fibres reinforced polyester polymer composites is detailed in Table 1. The coir nanofillers were mixed thoroughly with resin. Square shaped chromium-plated Mild steel moulds (of side 30 cm) were placed on the worktable of the compression testing machine (CTM). The wax was applied on the moulds for nonsticking of composite to mould and easy for releasing the composite from the mould. The selective length of Gallus-Gallus fibres was used as per research design in synthesizing a class of

Table 1: Research design.

Composites	PC*	CPP C1	CPP C2	CPP C3	CPP C4	CPP C5	CPP C6	CPP C7	CPP C8	CPP C9	CPP C10	CPP C11	CPP C12
Length of feather Gallus-Gallus fibres	—	5	5	5	10	10	10	15	15	15	20	20	20
Weight percentage of polyester	100	90	80	70	90	80	70	90	80	70	90	80	70
Weight percentage of Gallus-Gallus fibres	0	8	16	24	8	16	24	8	16	24	8	16	24
Percentage of waste coir nanoparticles	0	2	4	6	2	4	6	2	4	6	2	4	6

*Control specimen.

composite. The extreme layers are polyester in between layers and are alternate sequence appropriate long fibres and matrix material. Hence, out of five layers, the Gallus-Gallus fibres were placed in the second and fourth layers. After completing all five layers, the undried composite was compressed by compression testing machine (CTM). This causes the excess resin and air gaps/air bubbles removed from the composite and finished with uniform thickness. The composite was kept in CTM for 6 to 10 minutes and maintained the temperature of 120°C with a uniform load of compression of 2000 kg to avoid the bending while setting of composites [3]. After that, composites panel was allowed to dry on the rooftop for 5 to 6 days. In the same way, all 13 kinds of composite panels were synthesized. The chemical treatment of Gallus-Gallus fibres supports well in synthesizing the composites and found good bonding with the matrix. The surface finish of the composite was also found good.

2.6. Characterization of Moisture Absorbability. The samples were warmed up at 50 to 60 degrees Celsius for discarding the moisture content in the composite sample panels. Then, they were measured in all the dimensions and mass of each specimen. The specimens were immersed in the distilled water bath for 120 hours. The weight gain and dimensional gain were noted every 12 hours gap. The rapid improvements were observed in the first few observations and then gradually stabilized. On the last day, that is, the fifth day, no more improvement was found in dimensions as well as weight gain. Hence, it was understood that the test is almost complete. The final readings were used for estimating the net moisture absorbed in grams and elongation computations. The observations were graphically presented, analyzed, and discussed in the next section.

2.7. Characterization of Tensile Properties. The sample specimens for characterization of tensile properties are shown in Figure 2. A 400,000 N capacity Universal Testing machine was employed in this investigation. The specimen and testing procedure is followed as per ASTM D3039. In an inch wider, 10 inches long rectangular-shaped specimenand the gauge length was 6 inches. A gradual load of a millimetre per minute speed was set. The investigation was performed at room temperature and in the spring season. The sample specimens for this investigation are shown in Figure 3. The observations were graphically presented, analyzed, and discussed in the next section.

2.8. Characterization of Flexural Properties. The bendability of material is also a fundamental characteristic of a material. This is usually carried out in the position of a simply supported beam with a load on its midspan. That is, the reaction load at each endpoint and the loading at the middle point. The same universal testing machine is employed for this investigation and the loading speed was a millimetre per minute. A half an inch wider 6 inches long and 3 mm thicker specimens were used as per the standard of ASTM D790. The test was carried out at room temperature in spring atmospheric conditions. The observations were graphically presented, analyzed, and discussed in the next section.

2.9. Characterization of Tribological Property. The wear resistance is one of the tribological properties. The test (standard D4060-14) was carried out to characterize the Gallus-Gallus fibres reinforced polyester polymer composites and neat polymer composite in terms of wear resistance property. The Taber abrasers, Model ISE AO16 is employed in this investigation with a setting of revolution of turntable 1000 per minute for five hours for each 6.35 mm thick round sample with the surface area of 100 square millimetres. After 5 hours, the loss of weight of the specimens was measured for knowing the wear resistance of samples of each fibre length category and neat polyester composite. The observations were graphically presented, analyzed, and discussed in the next section.

2.10. Characterization of Properties Based on Dynamic Mechanical Analysis. The DMA Q800 V20.6 Build 24 is employed for executing the dynamic mechanical analysis in the composites. It is a kind of bending mode investigation. The 3 mm thick, 1/2″ × 2 1/2″ sized rectangular specimens were used. The heating rate of 4 degrees Celsius per minute is in the range of 28 to 230 degrees Celsius, and the vibration frequency is 1 Hz. Figure 4 shows results of the dynamic characterization. The observations were graphically presented, analyzed, and discussed in the next section.

The tensile tested specimen samples are shown in Figure 5. The special treatment of Gallus-Gallus fibres brings basic required strength into all kinds of composites. The detailed analysis and discussion of their characterization results were presented in the next section.

3. Results and Discussion

The 12 types of Gallus-Gallus fibres reinforced polyester polymer composites and neat polymer composites were

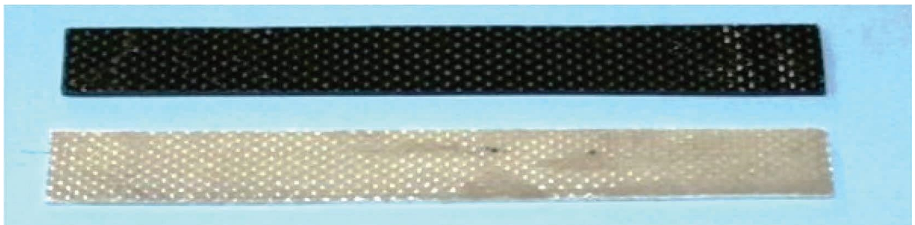


Figure 2: Tensile test specimen of specially treated selective Gallus-Gallus fibres reinforced polyester polymer composite and neat polymer composite.

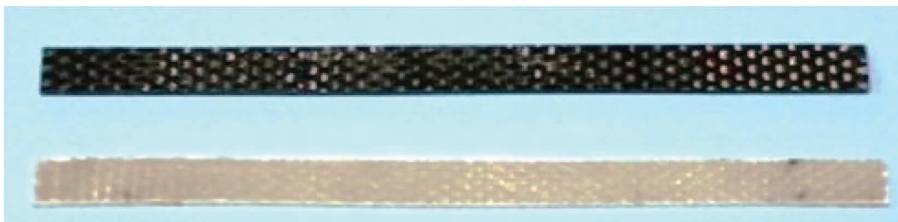


Figure 3: Flexural test specimen of specially treated selective Gallus-Gallus fibres reinforced polyester polymer composite and neat polymer composite.

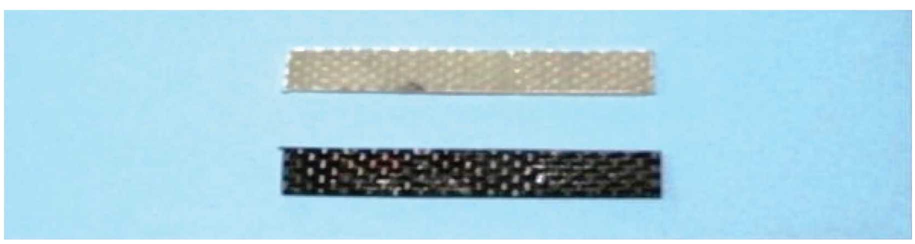


Figure 4: Dynamic mechanical analysis specimen of specially treated selective Gallus-Gallus fibres reinforced polyester polymer composite and neat polymer composite.

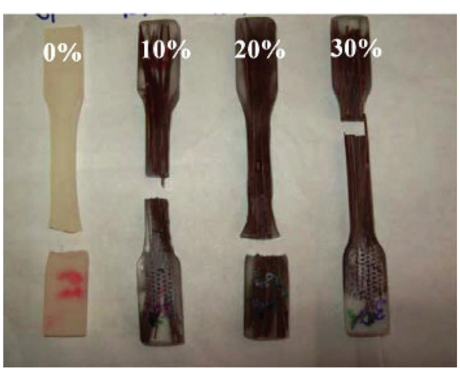


Figure 5: The tensile tested specimens of specially treated selective Gallus-Gallus fibres reinforced polyester polymer composite and neat polymer composite.

synthesized and characterized with static and dynamic mechanical analysis. Their observations are presented in this section as graphical outputs. In this section analysis of the results of the investigation is presented in detail. To evaluate the effectiveness of Vol. % of fibres and length of fibres used in Gallus-Gallus fibres reinforced polyester polymer composites, Tukey's multiple range test is employed for analyzing the results of static analysis. In MINITAB 17 software, the significance level of value is set as p less than 0.05. The comparative analysis is presented in this section sequentially.

3.1. Tensile Load-Based Characterization. The tensile test observations are presented in graphical form with Tukey test results in Figure 6. The test results reveal that neither neat polyester composite nor 5 mm and 20 mm long fibres used composites categories Gallus-Gallus fibres reinforced polyester polymer composites are strong. The preferable composite matrix (tensile strength is 16.5 MPa) is 80% polyester and 20% Gallus-Gallus fibres (with a selective length of 15 mm). The Tukey test results reveal that within the 10% fibre cases, the composite CPPC4 outperforms and the composite CPPC7 is more significant than composite CPPC1, composite CPPC4, and composite CPPC10 as per means of standard error ± SE at the level of $P \leq 0.05$. As logically compared to other wt% composites, the increase in tensile strength of 10 wt% composites is expected to increase up to composite CPPC7. This ambiguity in the result may be due to some inherent defects of synthesizing. The ostensible plunge in the tensile modulus was demonstrated in the case of 30 wt% fibre reinforced composites. The reason behind this fact is the lack of fibre dispersion.

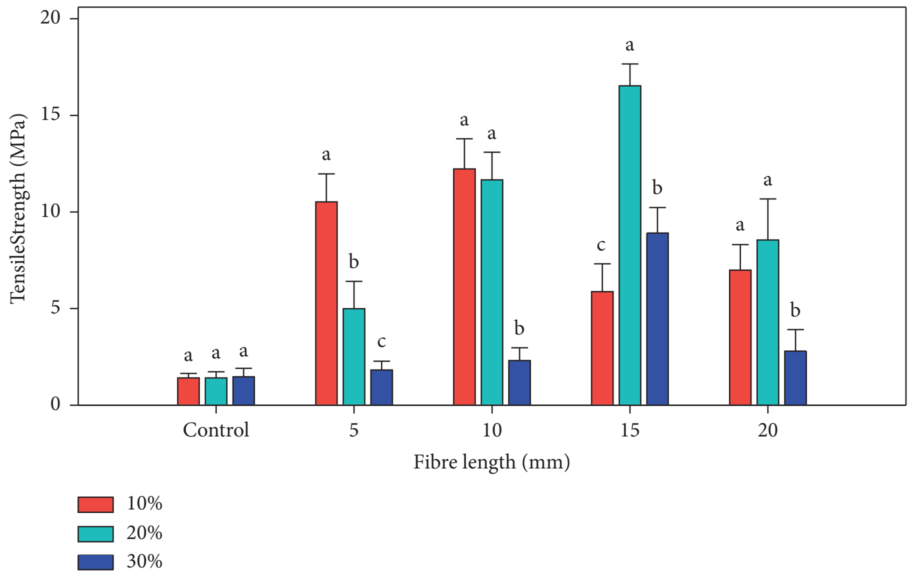


Figure 6: Tensile strength specially treated selective Gallus-Gallus fibres reinforced polyester polymer composites and neat polyester composite with Tukey test results.

The dispersion of fibres usually happens in the situation of fibre agglomeration. The neat composite has a tensile strength of 1.41 MPa.

In Figure 6, from left to right, the first three bars indicate control specimens, so no variation observed. The next 12 bars indicate the performance of composite specimen CPPC1 to CPPC12. It can be observed that within the 15% fibre cases, the composite CPPC8 outperformed. According to Tukey test results, the composite CPPC2 is more significant than composite CPPC4, composite CPPC6, and composite CPPC8 as per means of standard error ± SE at the level of $P \leq 0.05$. In the Tukey test results of 30% fibre cases, the composite CPPC3 is more significant than the control specimen than composite CPPC6, composite CPPC9, and composite CPPC12 as per means of standard error ± SE at the level of $P \leq 0.05$.

The tensile modulus of Gallus-Gallus fibres reinforced polyester polymer composite and neat polymer composite is shown graphically by the Tukey test result in Figure 7. In Figure 7, from left to right, the first three bars indicate control specimens so no variation is observed. The next 12 bars indicate the performance of composite specimen CPPC1 to CPPC12. It can be observed that the Tukey test results reveal that according to tensile modulus there is no significance as per the length of the fibres used, but the quantity of fibres used is significantly deferred as per means of standard error ± SE at the level of $P \leq 0.05$. The highest tensile modulus obtained for 10 mm long fibres used composites like CPPC4, CPPC5, and CPPC6. The CPPC5 found the highest value of 760.89 MPa compared to the tensile modulus of CP (213.32 MPa).

3.2. Flexural Test-Based Characterization. The flexural strengths of Gallus-Gallus fibres reinforced polyester polymer composite and neat polymer composite show graphically the Tukey test result in Figure 8. In Figure 8, from left to right, the first three bars indicate control specimens so no variation is observed. The next 12 bars indicate the performance of composite specimen CPPC1 to CPPC12. It can be observed that the increase of fibre content in the composite increases the flexibility; that is, flexural strength improved and the highest values were obtained for the composite CPPC12 (41.58 MPa) followed by CPPC11 39.35 MPa. The flexural strength of the PC is 29.14 MPa. In terms of flexural strength, the Tukey test results, it is understood that there is no significant difference between composite as per means of standard error ± SE at the level of $P \leq 0.05$. That is, all the prepared composites are sufficiently flexible.

The flexural modulus of Gallus-Gallus fibres reinforced polyester polymer composites and neat polymer composites is shown graphically with the Tukey test result in Figure 9. In Figure 9, from left to right, the first three points (same one over another) indicate control specimens, that is, variation observed. The next 12 points indicate the performance of composite specimen CPPC1 to CPPC12. It can be observed that the increase of fibre content in the composite increases the flexibility that improves flexural modulus and the highest values obtained for the composite CPPC12 (5441.32 MPa) followed by CPPC11 as 5278.95 MPa. The flexural modulus of PC is 2032.23 MPa. According to the flexural strength-based Tukey test result, it is understood that there is a significant difference of 10% fibre category composites (red) as per means of standard error ± SE at the level of $P \leq 0.05$, starting from 10 mm fibre length category and increased gradually with the increase of fibre lengths.

3.3. Wear Resistance-Based Characterization. The observation of weight losses Gallus-Gallus fibres reinforced polyester polymer composites and neat polymer composite is

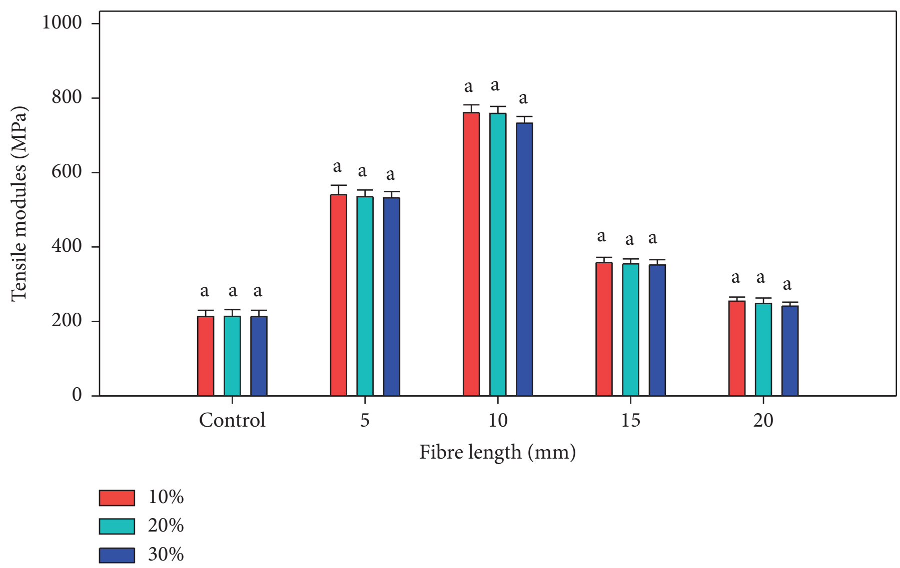


FIGURE 7: Tensile modulus specially treated selective Gallus-Gallus fibres reinforced polyester polymer composites and neat polyester composite with Tukey test results.

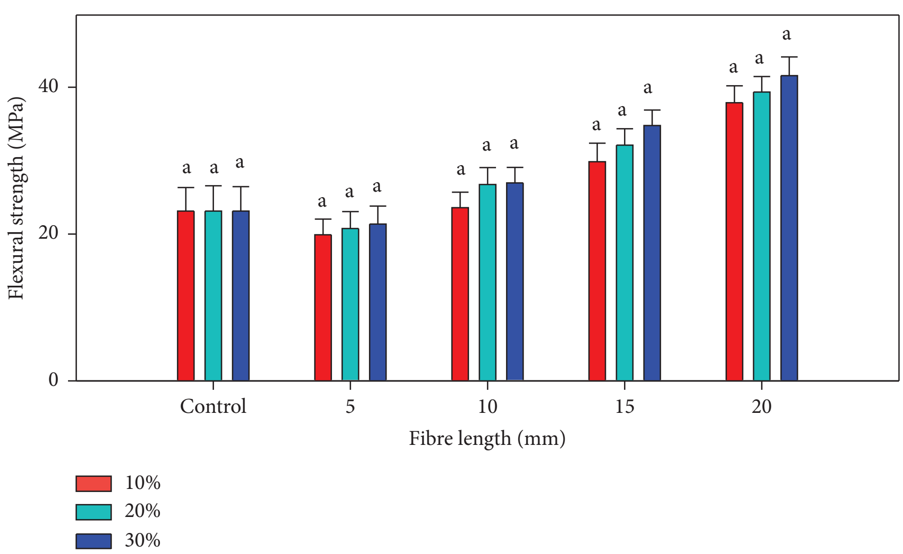


FIGURE 8: Flexural strength of specially treated selective Gallus-Gallus fibres reinforced polyester polymer composites and neat polyester composite with Tukey test results.

graphically presented along with Tukey test results in Figure 10. In Figure 10, from left to right, the first three points (same one over another) indicate control specimens, that is, variation is observed. The next 12 points indicate the performance of composite specimen CPPC1 to CPPC12. It can be observed that the special treatment on the Gallus-Gallus fibres supported well enhancements across all the fibre contents used. At lower weight fractions, the sample of CPPC1 (reinforced with 10 wt% (5 mm length of fibre)) had the most wear resistance because it had the least weight loss upon abrasion with a value of 0.1989 g among the treated CFF reinforced composites followed by samples containing 10 wt% (10 mm length of fibre) contents having increasing weight loss values of 0.2156 and 0.3998 g. A critical look at the graph revealed that the reinforcement of Gallus-Gallus fibres promotes wear resistance. So, wear resistance improves with the increase of vol. % of Gallus-Gallus fibres. The wear resistance is comparatively so much better than the no fibre reinforcement (neat polyester) had the least wear resistance and the overall highest weight loss value of 2.954 g. This indicates that the reinforcements improved the abrasion resistance of the developed composites.

3.4. Characterization of Moisture Absorption Property. The observation of net moisture absorbed by the Gallus-Gallus fibres reinforced polyester polymer composites and neat polymer composite in grams of weight gain is presented

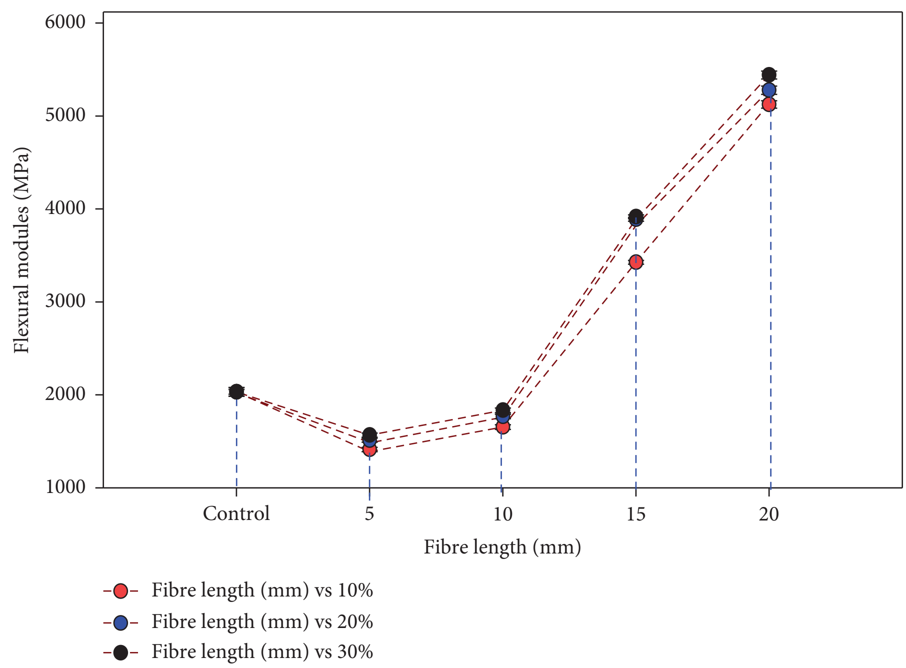


Figure 9: Flexural strength of specially treated selective Gallus-Gallus fibres reinforced polyester polymer composites and neat polyester composite with Tukey test results.

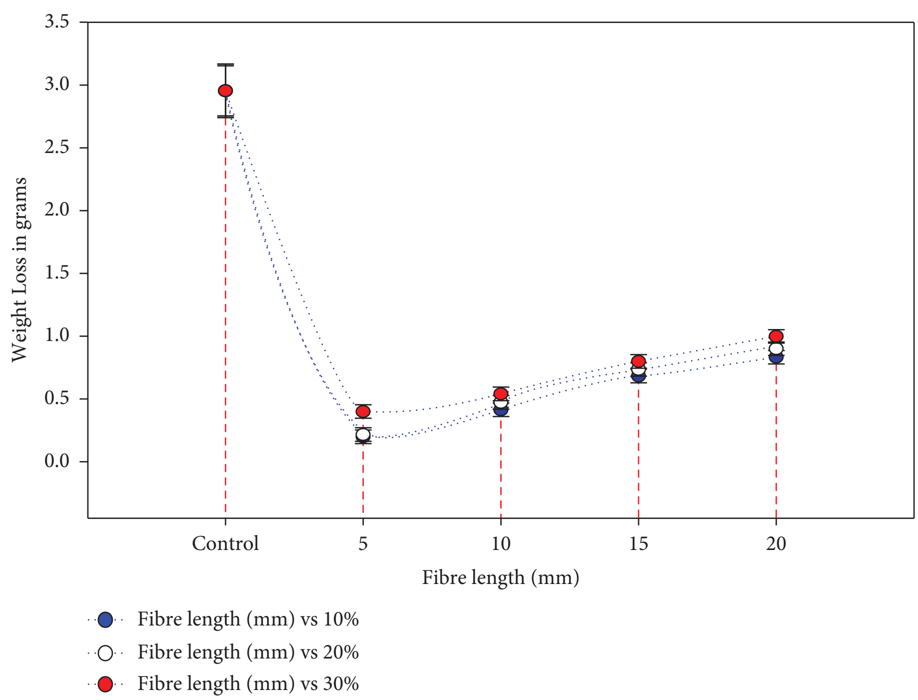


Figure 10: Wear property of specially treated selective Gallus-Gallus fibres reinforced polyester polymer composites and neat polyester composite with the Tukey test results.

graphically along with the Tukey test results in Figure 11. In Figure 11, from left to right, the first three bars indicate control specimens so no variation is observed. The next 12 bars indicate the performance of composite specimen CPPC1 to CPPC12. It can be observed that there are five groups such as neat composite, Gallus-Gallus fibres (length 5 mm, 10 mm, 15 mm, and 20 mm) reinforced polyester polymer composites. As per the Tukey test result, there are no significant differences in variation of fibres reinforcement in composites, but in a variation of the length of the fibres.

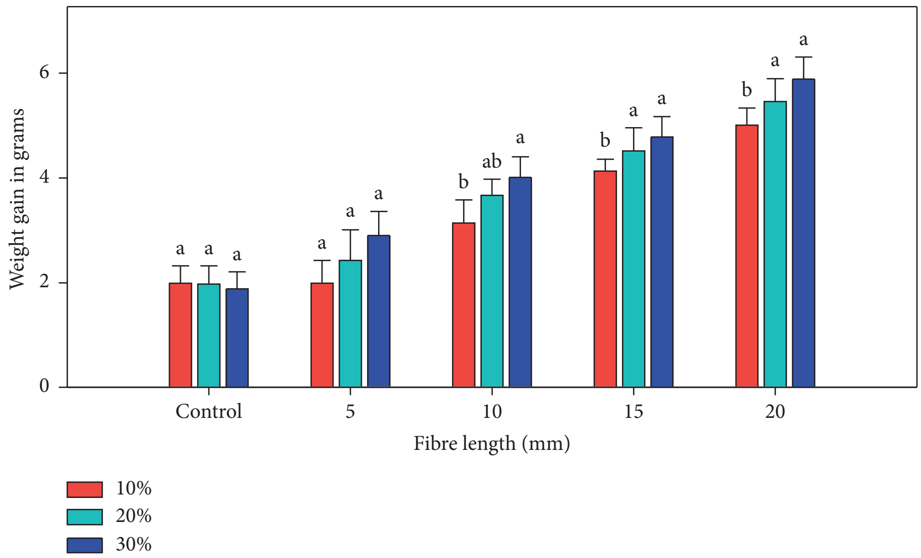


Figure 11: The moisture absorbability of specially treated selective Gallus-Gallus fibres reinforced polyester polymer composites and neat polyester composite with the Tukey test results.

In general, it is found that an increase in fibre content and an increase in the length of fibres are used directly in proportion to the weight gain by moisture absorption. The highest gain weight by composite CPPC12 by moisture absorption was 5.8 g.

3.5. Microscopic Analysis. The microscopic analysis was carried out employing the scanning electron microscopy test image of tested composite specimen of CPPC12. The uniform distribution of Gallus-Gallus fibres in the polyester matrix is ensured. The self-explanatory image of scanning electron microscopy is shown in Figure 12. The CFF in the SEM image meant chicken feather fibres (Gallus-Gallus fibres).

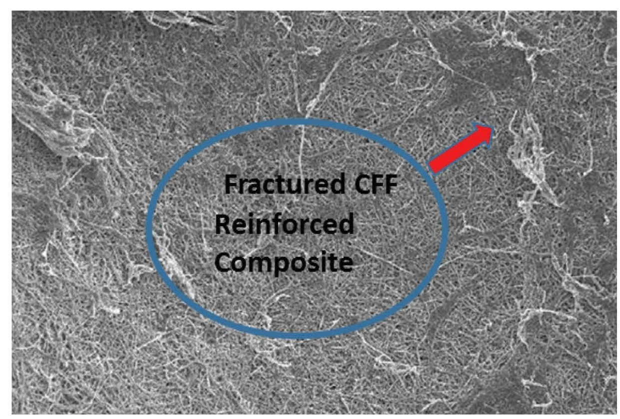


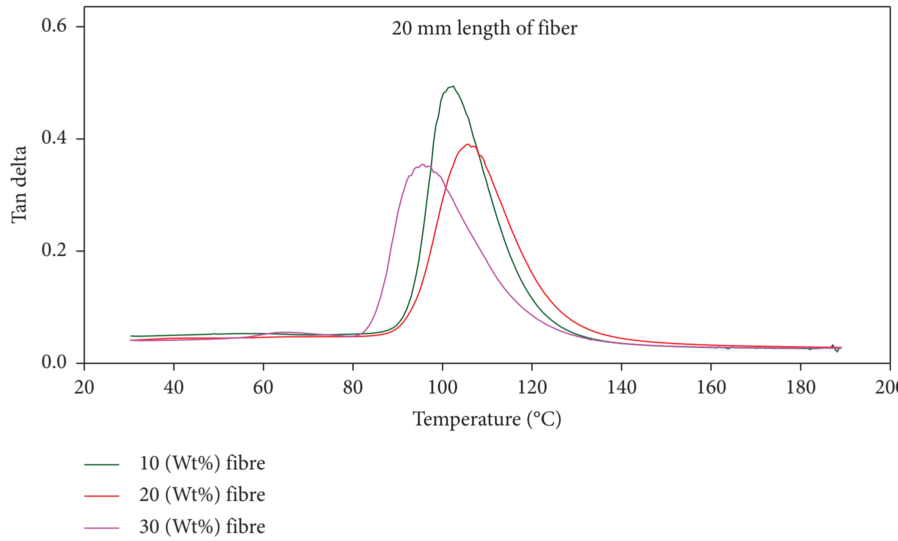
Figure 12: Scanning electron microscopy image of specially treated selective chicken feather fibres (CFF) reinforced polyester polymer composite of CPPC12.

3.6. Analysis of the Dynamic Mechanical Analysis-Based Characterization

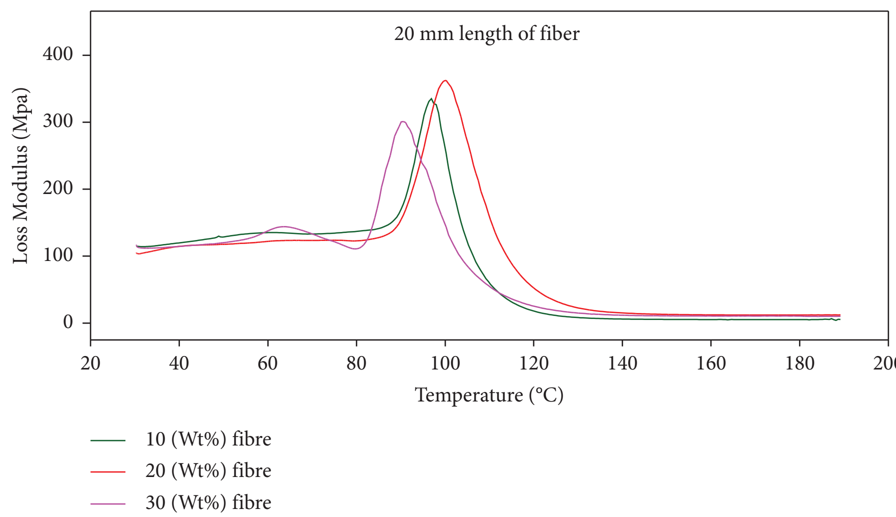
3.6.1. Dynamic Mechanical Analysis for Storage Modulus (E′). Usually, the frequency of 1 Hz is maximum in a diverse natural fibre ratio in the storage module (E′), particularly the bio-composites. The storage modulus is indirectly proportional to tan delta. The dynamic mechanical analysis results of the storage module were statistically between the diverse natural fibres of CPPC12 composite. The values were significant at the maximum temperature of 90.27°C and it is significant with 20 wt% and 10 wt% composites of CPPC11 and CPPC10 with 89.58°C and 82.67°C, respectively. The storage modulus curves also illustrated that the biologically derived composites integration increases the E′ values significantly.

3.6.2. Dynamic Mechanical Analysis for Loss Modulus (E″). The dynamic mechanical analysis curves (Figure 13) of the loss modulus showed that the fibres of composite CPPC12 reached maximum dissipation of mechanical energy with 362.0 MPa as compared to composite CPPC11 with 320.11 MPa, whereas CPPC10 with 318.29 MPa. It is also clearly evident that in the loss modules data, the consolidation of diverse types of bio-composite composition lands the extension of the loss modulus peak percentage, as a result of the amplification in procession separation.

3.6.3. Dynamic Mechanical Analysis of Composites Based on Tan Delta. The tan data results are displayed in Figure 13. The loss modulus to storage modulus is a ratio (E″/E′) which is base for considering the damping results [21]. In general, combination of natural fibres ratio grades the behaviour of damping in bio-composites; it is generally owing to the shear-stress (Ꞇ) dosage with fibres combined in the company of energy of viscos-elastic indulgence on natural fibre matrix [12]. These experimental results support [1] chicken feather fibre (CFF) in the matrix of poly-lactic acid (PLA) improving



(a)



(b)

Figure 13: The results of dynamic mechanical analysis of specially treated selective Gallus-Gallus fibres reinforced polyester polymer composites CPPC10, CPPC11, and CPPC12. (a) Tan data. (b) Loss modules.

the maximum stiffness, that is, the tensile modulus of 4.2 GPa [8]. Chicken feather fibre reinforced composites improved the mechanical, thermal, and electric properties [24].

The above results in the CPPC12 composite, the significant peak area of 0.362 delivered at 89.62°C as compared to the CPPC11 composite (0.398 at 111.26°C) and CPPC10 Composites (0.526 at 105.16°C). Hence, it is clear that the storage modulus of the composites decreased with the increase of Gallus-Gallus fibres reinforcement; hence, the mechanical loss factor (tan delta) decreased with the increase of Gallus-Gallus fibres reinforcement. The sign of augment of storage modulus offers elevated stability, as replicated in the modulus behaviour, and reduction of Tan delta peak is a sign of physically powerful interface [10].

Chicken feather fibre (CFF) in the matrix of poly-lactic acid (PLA) improved the maximum stiffness, that is, trensile modulus of 4.2 GPa. Chicken feather fibre reinforced composites improved the mechanical, thermal, and electric properties. Gallus-Gallus fibres and jute fibre combined at 50/50 fibre wt% for highest impact strength [25]. Aluminum diethyl phosphinate, ammonium polyphosphate, reinforced thermoplastic polyurethane, and aluminum hypophosphite are used to enhance flame retardant properties of Gallus-Gallus fibres composite [26]. The Gallus-Gallus fibres associated with human hair fibre in unsaturated polyester resin matrix in which the composition human hair 40 (Wt.)%, Gallus-Gallus fibres 10 (Wt.)% remaining 50 (Wt.)%, matrix recorded 183 MPa flexural strength, and 108.3 MPa compressive strength [27].

4. Conclusions

This research focused on increasing the utility value of universally as well as abundantly available Gallus-Gallus fibres and waste coir fibres. The Gallus-Gallus fibres were pretreated and specially treated with sodium and potassium manganate VII solution. The Gallus-Gallus fibres are selectively used in synthesizing composites in terms of wt% (10%, 20%, and 30%) as well as length (5 mm, 10 mm, 15 mm, and 20 mm) of Gallus-Gallus fibres. The waste coir powders were used as nanofillers. The specific outcomes are consolidated as follows:

Moisture absorption, depending upon the content of (Wt. %), specially treated selective Gallus-Gallus fibres in the composite matrix as well as the length of fibres used. Both are directly proportionate to the quantity of absorption of moisture. Although the maximum of 5.8 g weight gain found in 20 mm fibres used 30% Weight contributed CPPC12 composite.

The maximum tensile strength of 16.5 MPa was observed for composite CPPC10, that is, 80% polyester and 20% Gallus-Gallus Fibres of the selective length of 15 mm.

The highest tensile modulus obtained for 10 mm long fibres used composites like CPPC4, CPPC5, and CPPC6 which for CPPC5 tensile modulus was found highest as 760.89 MPa.

The highest flexural strength observed for the composite CPPC12 was 41.58 MPa and CPPC11 was 39.35 MPa.

The highest flexural modulus observed for the composite CPPC12 was 5441.32 MPa and then CPPC11 at 5278.95 MPa.

The maximum wear loss of 1.12 g was observed on the CPPC12 composite at 5000 rpm speed for 240 minutes of the tested specimen. Hence, the entire range of the proposed specially treated selective Gallus-Gallus fibres reinforced polyester polymer composites has good wear resistance

Based on the abovementioned results, the composites CPPC10, CPPC11, and CPPC12 are considered for microscopic examinations and dynamic mechanical analyses. The microscopic examination ensured the uniform distribution of selective Gallus-Gallus fibres in the polyester resin matrix. The dynamic mechanical analyses concluded that the mechanical loss factor that is tan delta decreased with the increase of Gallus-Gallus fibres reinforcement. That is, the augment of storage modulus offers elevated stability, as replicated in the modulus behaviour and reduction of tan delta peak is a sign of the physically powerful interface. Overall, the composite CPPC12 outperformed well.

The practical implications would be the utility value of Gallus-Gallus is focused on. The proposed composites properties are spread from sufficient strength to good strength, so a wide range of applications can be identified such as construction, doors, shelves, furniture, automotive, and upholstery.

Data Availability

The data used to support the findings of this study are included in the article. These are available from the corresponding author upon request.

Disclosure

The study was performed as a part of the Employment Hawassa University, Ethiopia.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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