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Research Article

Formation and Customer Evaluation of Eco-Friendly Shoe Polish Using Banana (Musa spp.) Peel and Coconut (*Cocos nucifera*) Shell Charcoal.

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Abstract

This research aimed to develop an environmentally friendly shoe polish using banana (Musa spp.) peel and charcoal derived from coconut (*Cocos nucifera*) shell. Four distinct shoe polish formulations were prepared by changing the quantity of banana peel extract (10 g: C1, 20 g: C2, 30 g: C3, and 40 g: C4) while maintaining a constant ratio of coconut shell charcoal as a primary component. A commercially available shoe polish (C5) served as the control sample. Various characteristics, including shine, quick-drying, water resistance, rub resistance, and fading resistance, were assessed post-application on three types of shoes: school shoes, leather shoes, and safety shoes. A customer satisfaction survey involving thirty participants was conducted to evaluate the performance of the shoe polish on the aforementioned shoe types. The survey results indicated that C5 exhibited satisfactory outcomes on school shoes but performed poorly on safety shoes, while C4 demonstrated favorable results on the other two shoe types. Higher banana peel content increased shine, quick-drying, water resistance, and rub resistance. The outcomes highlight the significant potential of the banana peel and coconut shell charcoal-based shoe polish as a sustainable and environmentally friendly alternative to commercial products. Moreover, the study findings propose that this formulation could provide environmentally conscious consumers with a natural and viable option for footwear maintenance.

Keywords: Banana peel extract, Coconut shell charcoal powder, Customer satisfaction

1. Introduction

Shoe polish is a paste, cream, or liquid that is used to improve the shininess and increase the life and aesthetic appeal of footwear. It contains ingredients like waxes, dyes, and solvents that nourish leather, restore colour, and create a protective barrier against dirt and moisture (Charles, 2019). Shoe polish is prepared by using a mixture of natural and synthetic materials that include wax, lanolin, naphtha, ethylene glycol, turpentine, oil-soluble dyes, and gum arabic using chemical engineering processes (Charles, 2019; Parihar and Chaudhary, 2023). Apart from these, natural materials, including banana peel, beeswax, tallow, mango shell, and charcoal, have been used in the preparation of shoe polish for many years (Parihar and Chaudhary, 2023).

Shoe polish properties such as gloss, colour consistency, coverage, water resistance, conditioning, shine, quick drying, and durability are crucial for maintaining and enhancing the appearance of footwear (Akinbomi *et al*., 2022). Achieving a lasting shine, fast drying time, and long-lasting protection are key considerations in selecting an effective shoe polish. The properties mentioned are contingent upon the materials chosen for the production of shoe polish. The surge in environmental consciousness has spurred a rise in demand for eco-friendly shoe care products. Consumers are gravitating towards sustainable choices that cater to both shoe maintenance and environmental stewardship. Towards this, in this study, banana peel and coconut charcoal are used as environmentally friendly materials for shoe polish production.

Initially viewed as waste, banana peels have emerged as a valuable resource with applications across various industries. They are utilised in medicine, as emulsifiers, biofertilizers, biosorbents, natural preservatives, and for food fortification purposes (Aboul-Enein *et al*., 2016; Agama-Acevedo *et al*., 2016; Yasin *et al*., 2025). When compared to other fruits, banana peels have a higher concentration of phenolics, which are significant secondary metabolites (Vu *et al*., 2018). Banana peel has a relatively high amount of minerals, including phosphorus 22.2 mg, calcium 18 mg, potassium 50.0 mg, and magnesium 11 mg (Afzal *et al*., 2022). Raw banana peels are used in shoe polish to improve the shine and water repellence of leather. Banana peel includes high levels of calcium and potassium, which can work as a cleaning and shining agent for leather surfaces (Akter and Parvin, 2018).

Coconut shells are a common agricultural waste which is used as the raw material for activated carbon, barbecue charcoal and shisha briquettes (Yirijor and Bere, 2024). Charcoal is a very good absorber, and it can absorb offensive smells. Because of its exceptional absorption and odour-control qualities, as well as its affordability and increased effectiveness, activated charcoal is utilised in the majority of industries (Madakson *et al*., 2012; Yirijor and Bere, 2024). It is also an eco-friendly black pigment, which is an alternative to synthetic black pigments. Lignin is one of the most significant ingredients in coconut shells, which functions as an emulsifier, dispersant, and binding agent (Wang *et al*., 2023). Charcoal gives a gloss appearance, rub resistance, and fade resistance to shoes. It forms a thin film on the surface of the shoe, providing protection and enhancing its appearance (Derbe *et al*., 2021). It helps to reduce foot odour and maintain a fresh smell in the shoes. Additionally, charcoal has a high adsorption capacity, allowing it to effectively remove impurities and pollutants from the shoes.

Only a limited number of studies have explored the use of banana peel and charcoal as ingredients in shoe polish. For instance, one study developed shoe polish utilising 5-15 g of banana peel powder in combination with beeswax, although the application of the polish on shoes was not tested (Akter and Parvin, 2018). Another study incorporated commercially available charcoal powder as a black dye and cactus (*Opuntia ficus-indica*) powder to create shoe polish, demonstrating its comparability to commercially available products (Derbe *et al*., 2021). However, none of the existing studies has combined both banana peel and charcoal derived from coconut shells in shoe polish production. Hence, this study was initiated to evaluate the feasibility of utilising these ingredients in shoe polish to enhance its characteristics.

2. Materials and Methods

2.1. Materials

Linseed oil, Paraffin oil, Ethylene glycol, Stearic acid, PEG 4000, Beeswax, Carnauba wax, Phenolic resin, Microcrystalline wax, Turpentine, Vanilla, Coconut shell charcoal, Banana peel.

2.2. Preparation of Coconut Shell Charcoal Powder

Cleaned coconut shells were collected and dried in the sunlight. Dried coconut shells were burned with a limited supply of air. After the completion of burning, water was sprayed on the burned shell particles before making ashes. Then, the burned coconut shell was dried in sunlight until the moisture was removed and ground into fine particles using a laboratory grinder (MRC Laboratory instruments, Israel). Ground charcoal powder was sieved into fine particles using a sieve and stored in a wide-mouth plastic bottle until use (Ahmad *et al*., 2022).

2.3. Preparation of Banana Peel Powder

Banana peels were washed with distilled water. Then they were dried for 2-3 days in the sun and followed by oven drying at 50°C. The dried peels were ground into powder using a blender. Ground peel powder was sieved into fine particles using a sieve (200 microns) (Figure 1) and stored in a wide-mouth plastic bottle in the refrigerator until use (González-Montelongo *et al*., 2010).

Figure 1. Preparation of banana peel powder: a) fresh banana peel, b) dried banana peel and c) dried banana peel powder.

2.4. Preparation of Banana Peel Extract

Banana peel powder of 10, 20, 30 and 40 g was mixed with 350 ml of hot water separately in bowls. After cooling, they were filtered using a fabric cloth (Figure 2). Filtered banana peel extract was heated using a hot plate at nearly 80°C until it became a paste.

Figure 2. Preparation of banana peel paste: a) boiling the banana peel powder, b) filtering the liquid, and c) banana peel paste.

2.5. Preparation of Shoe Polish

The ingredients, such as linseed oil, paraffin oil and ethylene glycol, were heated in an aluminium pot. Then, stearic acid, PEG 4000, Beeswax, Carnauba wax, Phenolic resin, and Microcrystalline wax were added to the pot and stirred using an iron spoon until melting. After melting them, banana peel paste and coconut shell charcoal were added to the mixture as shown in Table 1 and were mixed well. The mixture was heated until it turned into a smooth paste. Then the sample was mixed well using a shoe polish mixing machine at 800 rpm for 15 minutes. After the first mixing, vanilla and turpentine were added to the mixture. Then, for the second time, mixing was started at 600 rpm for 5 minutes. The samples were transferred into shoe polish containers. The polish samples were allowed to cool at room temperature. After two days, aluminium foil was added to the top of the shoe polish container and the lid was closed (Derbe *et al*., 2021). A commercially available shoe polish was used as the control sample.

Table 1: Amounts of banana peel powder and coconut shell charcoal added for shoe polish

Shoe polish sample	Amount of Banana peel powder (g)	Amount of Coconut shell charcoal (g)
C1	10 (2.76%)	70 (19.34%)
C2	20 (5.52%)	70 (19.34%)
C3	30 (8.29%)	70 (19.34%)
C4	40 (11.05%)	70 (19.34%)
C5	Control	Control

2.6. Determination of pH Value

A 15 g sample of shoe polish was added to 100 ml of distilled water in an Aluminium pot. The polish and water mixture was heated at 80°C with stirring until the shoe polish wax was melted. The wax cake was separated from the aqueous phase using a Whatman 40 filter paper. Then the pH value was determined using a pH meter (HI2020W, Hanna Instruments, USA) for triplicate samples (Derbe *et al*., 2021).

2.7. Evaluation of Customer Satisfaction Survey

For this study, three distinct types of shoes were chosen: school shoes, leather shoes, and safety shoes. A customer satisfaction survey was carried out involving thirty participants, each of whom received three questionnaires corresponding to the three types of shoes, totalling ninety sheets distributed among the thirty individuals. The customers were given clear instructions about the application method, amount and polishing time to maintain the uniformity. During the survey evaluation, properties such as shine, quick drying, water resistance, rub resistance, and fading resistance were assessed. A five-point rating scale was employed, with 1 representing "Very unsatisfied," 2 for "Unsatisfied," 3 for "Normal," 4 for "Satisfied," and 5 for "Very satisfied."

2.8. Statistical Analysis

The performance of each shoe polish was compared using the median value of the customer satisfaction level score. To determine the best shoe polish sample for a specific shoe type, a Friedman Test was conducted using the customer satisfaction level score for all tested properties in Minitab 18 (Minitab Inc, 2010). Subsequently, hierarchical cluster analysis was performed in Minitab 18 using the sum of ranks value obtained from the Friedman Test for each type of shoe (Abhiram *et al*., 2018). The shoe polishes grouped in the cluster analysis were considered the best shoe polishes for the particular shoe type. Similarly, to identify the best shoe polish for all types of shoes, cluster analysis was performed in Minitab 18 using the sum of ranks value obtained from the Friedman Test for all shoe types.

3. Results and Discussions

3.1. pH Value of Shoe Polish

The pH values of the prepared shoe polish samples were within the range of 5.80 to 6.64 (Table 2), which is marginally lower than 7, indicating the acidic nature. The optimal pH for shoe polish typically ranges between 6 and 8. A slightly acidic to neutral pH is preferred for shoe polish formulations as it helps maintain the stability and effectiveness of the product. pH levels outside this range may affect the consistency, colour, and application of the shoe polish (Adiova *et al*., 2024). Out of the newly developed samples, C1 and C4 fall within the recommended pH range.

Table 2: pH values of five shoe polish samples

Shoe polish sample	pH value
C1	6.05
C2	5.82
C3	5.80
C4	6.64
C5	6.52

3.2. Customer Satisfaction

Customer satisfaction regarding shoe polish properties, including shine, quick-drying, water resistance, rub resistance, and fading resistance, was collected and analysed across three types of shoes: school shoes, leather shoes, and safety shoes. Each shoe polish sample was rated on a scale of 1 to 5 according to customer satisfaction.

3.2.1. Shine of Shoe Polish Samples

The shine provided by five different shoe polish samples on school shoes, leather shoes and safety shoes is presented in Figure 3. The C1 sample gave better shine for school and safety shoes than leather shoes. The C2 sample provided shininess in the order of school shoe, safety shoe and leather shoe. Sample C3 gave equal shine on all shoe types. Sample C4 gave equal shine on leather and safety shoes, but a lower value on school shoes. Shininess of commercial product (C5) on school shoes was the highest of all samples, but gave very poor shininess on the safety shoes. For school shoes, leather shoes and safety shoes, shoe polish samples C5, C4 or C5 and C4 gave the highest shininess, respectively. The overall performance of the C4 sample was good on all shoe types. When the amount of banana peel increases, the shine of the shoe polish also increases (Akter and Parvin, 2018; Akinbomi *et al.*, 2022). This could explain the highest shine observed in the C4 sample, as it contains a higher amount of banana peel compared to the other samples.

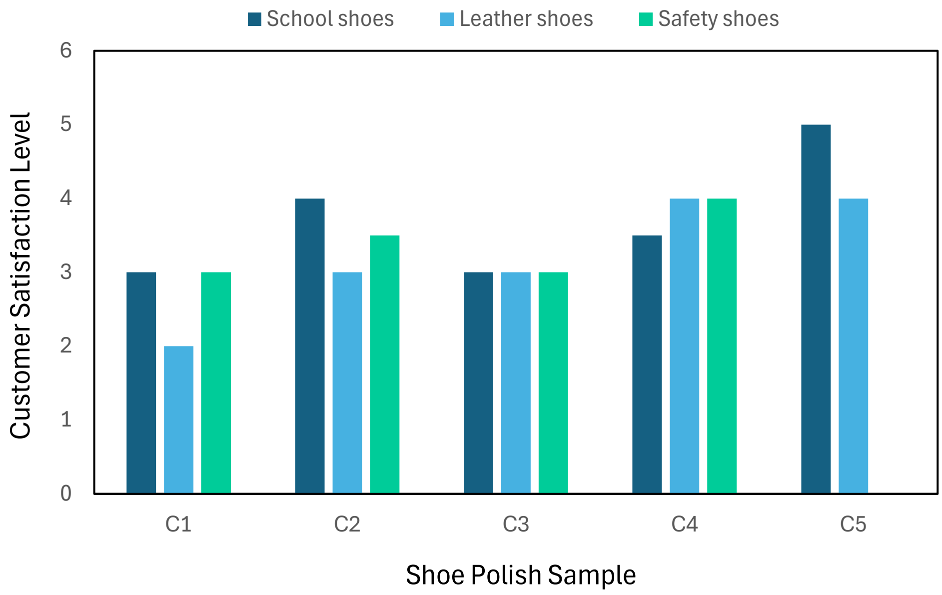

Figure 3. Shine of shoe polish samples on different shoe types

3.2.2. Quick-drying Ability of Shoe Polish Samples

Quick drying of shoe polish is crucial to prevent it from spreading on clothing or other materials. Both C1 and C3 samples exhibited similar ratings for quick drying across all types of shoes (Figure 4). Sample C2 received the highest satisfaction level for school shoes compared to other shoe types. The satisfaction level of the C4 sample was equal for school and leather shoes, surpassing the satisfaction level for safety shoes. The commercial product (C5) garnered the highest satisfaction level for both school and leather shoes compared to the other shoe polish samples. However, its satisfaction level was notably low (median = 0) for safety shoes. Despite this, sample C4 received the highest overall acceptability among consumers when considering all shoe types. This shoe polish contains the highest level of banana peel and turpentine, which functions as a quick-drying agent. A higher concentration of antioxidant and antimicrobial chemicals is present when the amount of banana peel is increased. Consequently, the quick drying of the shoe polish will also improve (Hikal *et al.*, 2022).

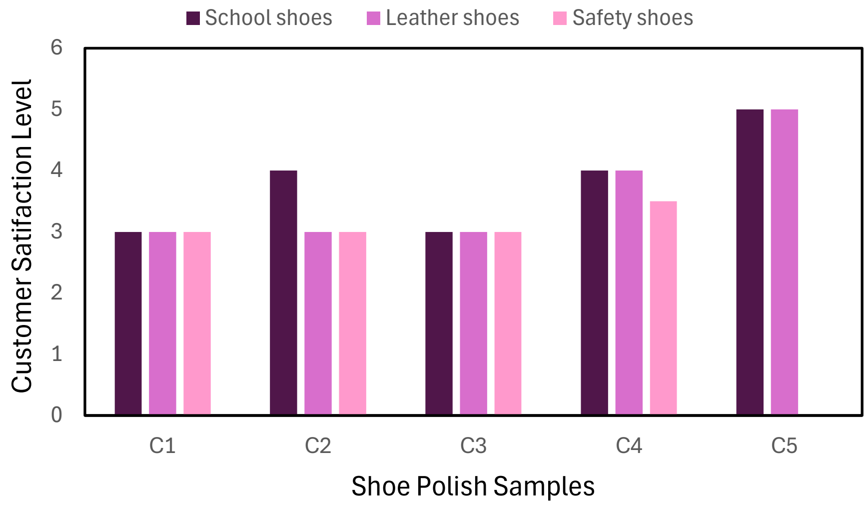

Figure 4. Quick-drying ability of shoe polish samples on different shoe types

3.2.3. Water Resistance in Shoe Polish Samples

Water resistance is crucial to ensure durability, protection against moisture damage, and long-lasting shine on shoes. The customer satisfaction levels for samples C2 and C4 were identical across all three types of shoes (Figure 5). Both of these samples demonstrated a high-water resistance score for leather shoes compared to the other two shoe types. Similarly, sample C1 received a better satisfaction score for leather shoes than for other shoe types. Sample C3 exhibited a similar score for leather and safety shoes but a lower value for school shoes. The commercial sample (C5) showed similar scores for school and leather shoes but a very poor score (median = 0) on safety shoes. Banana peel is considered a good choice for achieving water resistance, as it contains a significant amount of potassium and oil components that serve as water resistance agents (Akter and Parvin, 2018; Adiova *et al*., 2024). Therefore, increasing banana peel content increases the water resistance of shoe polish.

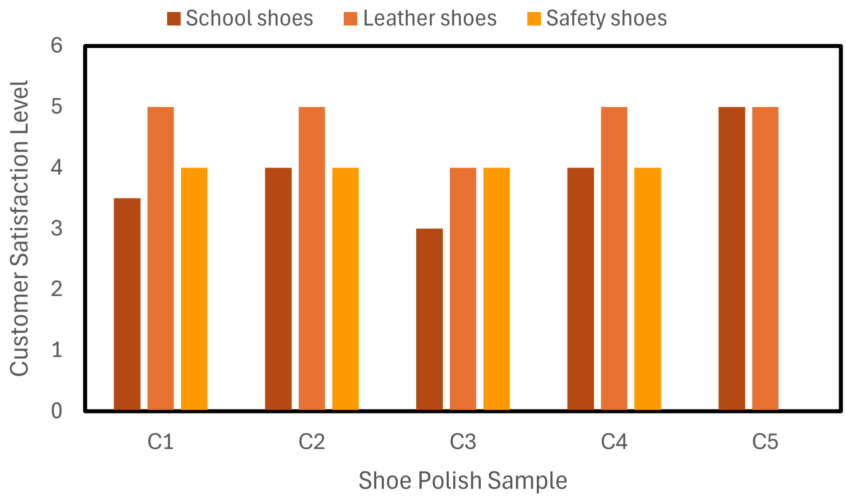

Figure 5. Water Resistance of shoe polish samples in different shoe types

3.2.4. Fading Resistance in Shoe Polish Samples

The fading resistance in shoe polish is essential to maintain the colour intensity and appearance of the shoes over time, ensuring a long-lasting and vibrant shine. Sample C1 received an equal customer satisfaction level value for all shoe types (Figure 6). The commercial sample (C5) recorded the highest value for school shoes. In the case of leather shoes, both the C4 and C5 samples received equal and the highest satisfaction scores. For safety shoes, both the C2 and C4 samples received equal and the best scores, while the satisfaction level of C5 on safety shoes was very poor. Overall, the performance of C4 was superior on all three shoe types compared to the other samples. Increasing the amount of charcoal can enhance the fading resistance of shoe polish (Derbe *et al*., 2021). All the samples in this study were formulated with approximately 19% (w/w) of charcoal, which may explain the high fade resistance demonstrated by these samples. Moreover, the higher score for sample C4 could be attributed to the increased holding ability of the blackness in the shoes, resulting from the higher banana peel content.

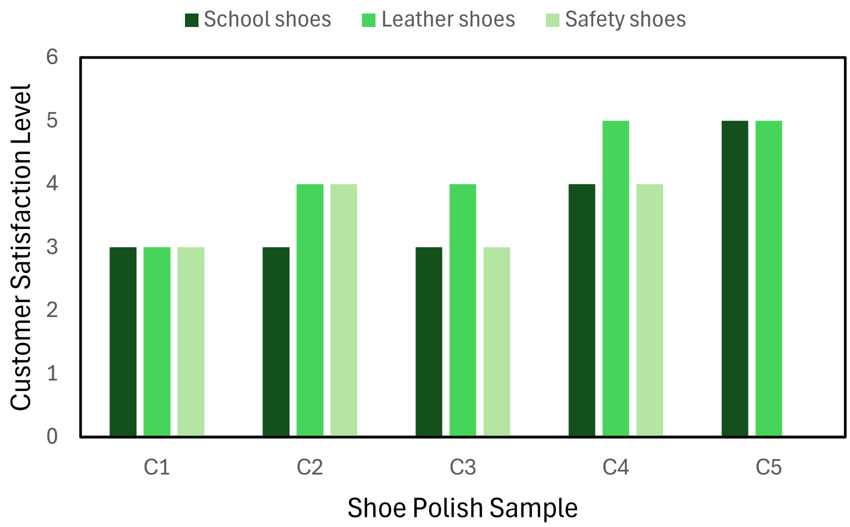

Figure 6. Fading Resistance of shoe polish samples in different shoe types

3.2.5. Rub Resistance in Shoe Polish Samples

Rub resistance is crucial as it ensures that the polish remains intact and does not easily wear off when the shoes are rubbed or scuffed during daily wear. This resistance helps maintain the polished appearance of the shoes for an extended period. Samples C1 and C2 received an equal customer satisfaction score on all types of shoes (Figure 7). Sample C4 received a similar score for school and leather shoes, while C1 received better results for safety shoes. Overall, the performance of sample C4 was superior to that of the other shoe polish samples.

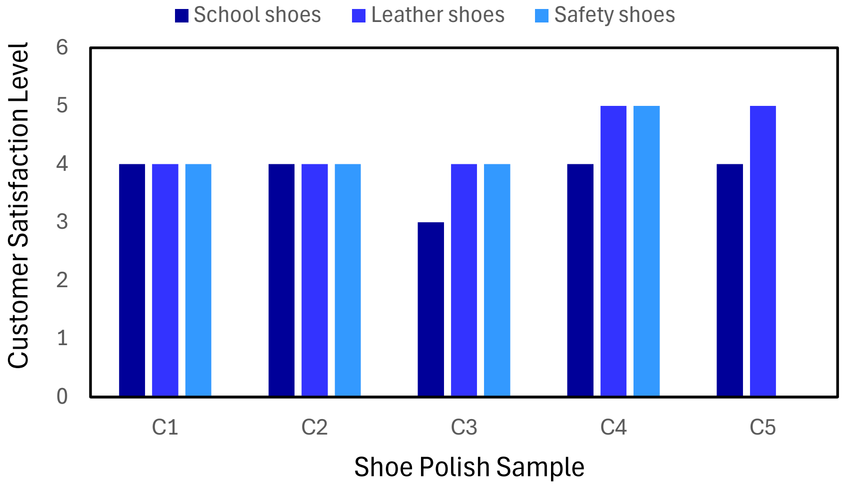

Figure 7. Chart of Rub Resistance in different shoe types

3.2.6. Overall Performance of the Shoe Polish on Each Shoe Type

To evaluate the overall performance of a shoe polish sample, cluster analysis was conducted using the sum of ranks value obtained from the Friedman Test. The best shoe polish for each type of shoe was chosen based on the groupings in the cluster analysis and the sum of the rank value. For school shoes, shoe polish samples C1 and C2 were grouped together at a distance of 40, while C3 and C4 were grouped together at a distance of 43 (Figure 8). Sample C5 was grouped separately from the other samples. The commercially available sample (C5) had the highest sum of ranks value and was grouped separately in the cluster analysis, indicating it is the best shoe polish for school shoes. Between C3 and C4, C4 had a higher sum of rank values and was separated from C2 at a distance of 10. Therefore, C4 is considered the second-best shoe polish sample.

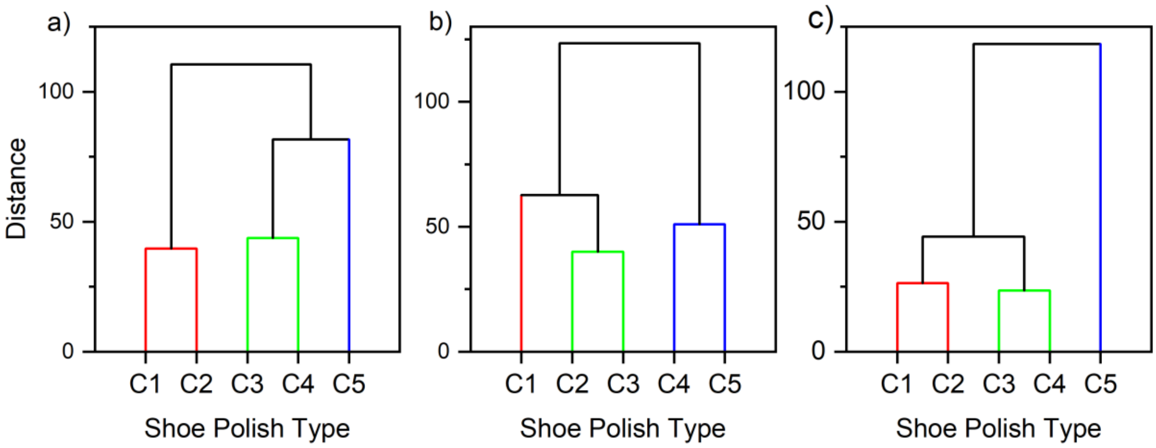

Figure 8. Cluster diagram for overall performance of shoe polish samples on: a) school shoe, b) leather shoe and c) safety shoe.

Considering the leather shoe, samples C4 and C5 were grouped together at a distance of 50, while samples C2 and C3 were grouped together at 40, and C1 was grouped separately (Figure 8). Both C4 and C5 were considered the best shoe polish samples for leather shoes based on the sum of rank values and cluster grouping. Sample C1 showed poor performance on leather shoes.

On safety shoes, samples C1 and C2 were grouped together at a distance of 26, while C3 and C4 were grouped together at 23 (Figure 8). The commercially available sample (C5) was separated from the other samples. Both C3 and C4 were performing well based on the sum of rank values and cluster grouping, with a slightly higher sum of rank values for C4 compared to C3. Surprisingly, the commercially available sample C5 performed poorly on safety shoes.

3.2.7. Overall Performance of the Shoe Polish on All Shoe Types

To determine the best shoe polish for all types of shoes, hierarchical clustering was conducted using the sum of ranks value obtained from the Friedman Test. In the clustering, samples C1 and C2 were grouped together, while C3 and C4 were also grouped together, with sample C5 positioned separately (Figure 9). Despite C3 being clustered with C4, the overall performance of C4 was significantly better than that of C3, making C4 the best shoe polish sample for all types of shoes. The next-best sample was C5; however, it is not recommended for safety shoes as it exhibited very poor performance in that category.

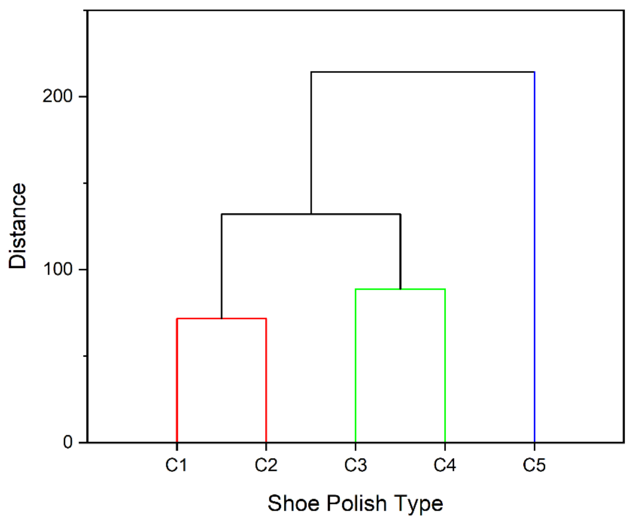

Figure 9. Overall performance of shoe polish types considering all shoe types together

This study evidence that banana peel is a good eco-friendly option to improve the shine, quick drying, and water-resistant properties of the shoes. Because it contains a very significant amount of potassium and calcium, which work as a cleaning, shining and water resistance agent (Akter and Parvin, 2018). Charcoal gave rub resistance and fading resistance to shoes. This study provides evidence that the combination of banana peel and charcoal resulted in superior overall performance across the tested properties on school, leather, and safety shoes.

4. Conclusions

Four shoe polish samples were prepared using banana peel powder and coconut shell charcoal and compared against a commercially available shoe polish sample (Control: C5) on three types of shoes: school shoes, leather shoes, and safety shoes. Based on all tested parameters, the commercially available sample performed well on school shoes, while sample C4 showed good performance on leather and safety shoes. Sample C4 contained a higher amount of banana peel powder content (11.05% w/w), which possibly contributed to its superior performance. Increasing the banana peel content in the shoe polish enhanced its shine, fade resistance, water resistance, and quick drying properties. This study indicates that banana peel and coconut charcoal are suitable ingredients for producing an eco-friendly shoe polish that is comparable to commercially available shoe polish samples.

Author Contributions

Conceptualization, J.V. and M.K.M.; methodology, M.H.S.T. and G.A.; validation, M.H.S.T.; formal analysis, G.A. and M.H.S.T.; writing—original draft preparation, G.A. and M.H.S.T.; writing—review and editing, G.A. and M.K.M.; supervision, G.A., J.V. and M.K.M.; project administration, J.V. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest: The authors declare no conflict of interest.

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