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Posted Date: 2 February 2024

doi: 10.20944/preprints202402.0151.v1

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Preliminary Mechanical Characteristics of Bio-Composite Materials Faux Leather Based on Orange Peel Waste

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Abstract: Naturally-derived synthetic leather is a widely used and high-quality type of faux leather or synthetic leather. Many consumers prefer authentic leather goods due to their exceptional qualities, including high water vapor permeability and superior wearing comfort. Consequently, the exploration of artificial leather made from natural materials with exceptional qualities as an alternative to genuine leather has garnered significant interest and is now a highly studied subject. Synthetic leather, sometimes known as imitation leather, has gained popularity recently as a highly suitable alternative to genuine leather. Continuous advances in this area of research increase the range of uses for synthetic leather using natural fibers. Thus, this research aims to explore synthetic leather materials using orange peel waste, which can be applied to the fashion industry. This research applies several types of orange peel waste, such as Pomelo, Sweet orange, and Sunkist orange, to different compositions and strengthening materials, such as bandages and dacron. The resulting bio-composite materials' morphology, mechanics, and adhesive properties were evaluated following ASTM D 2209-00 and ASTM D 4533-04 standards. The results indicate that specimen 1A (Pomelo using bandage as reinforcement) has the most significant effects, with a tensile test value of approximately 472 N/cm2, an elongation of roughly 67.28% was the highest value on sweet orange using bandage as reinforcement, and a tear resistance of around 14.28 N/cm2 for Pomelo with bandage as reinforcement. Furthermore, the test results also show that composition 2B still does not meet the standards of SNI 1294:2009 and ISO 3376 for tensile strength and ISO 3377-1 for tear strength. Additionally, statistical analysis showed no appreciable changes in the samples analyzed. Furthermore, statistical evaluations showed no significant alterations in the studied samples. The results of this experimental investigation can be explored further and used as a basic framework for the creation of bio-composites from orange peel waste for future fashion.

Keywords: synthetic leather; faux leather; orange peel; fashion; bio-composite

1. Introduction

This article looked into a revolutionary formulation technique to create leather items without using any animals while balancing affordability, accessibility, and environmental friendliness. There are several biodegradable polyester polymers combined with cellulose biomass from orange peel waste, which is processed from remaining agro-waste to make bio-composite materials. The bio-composite materials' morphological, mechanical, and adhesive properties are assessed for prospective textile applications. Over the past few decades, the fashion industry and scientific researchers have gradually pushed for the development of leather substitutes, leading to the design of numerous synthetic and natural materials [1,2]. Today, synthetic leather is an important material that is widely used in place of genuine leather in products, including clothes, footwear, sofa fabric, home decor, and car interiors [3]. Due to their consistent manufacture and lower production costs than genuine leather, these materials have a strong market [4]. A backing substance, a base coat, a middle coat, and a top coat are the typical components of artificial leather [5]. Although the fashion industry strives to offer products at fair prices with its continuously changing trends and designs, most consumers need to be aware of this industry's significant contribution to global pollution due to its vast waste production[2,6]. Additionally, using animal skin and other natural resources in manufacturing leather fashion products poses a severe danger to sustainability for current and future generations. Developing eco-friendly products and looking into alternate sources is essential [7].

Compared to natural leather, synthetic leather is an animal-friendly fabric. Split leather makes up the outside, which has a polyurethane PU covering embossed on it. Also, synthetic leather was brought up because it resembles natural leather. Genuine leather is of the most excellent caliber, durable, and long-lasting. Faux leather, conversely, is synthetic but has a comparable appearance and feel to natural leather. Despite not being as robust as genuine leather, it is still used to create stylish, cost-effective items. Although the aesthetic behavior of this imitation leather and that of genuine leather are comparable, several additional qualities significantly differ, most notably the permeability to water vapor. The collagen fibers of genuine leather contain more hydrophilic groups than those of synthetic leather, which is the critical distinction between the hygienic qualities of the two types of leather. Compared to natural leather, synthetic leather is an animal-friendly fabric. Split leather makes up the outside, which has a polyurethane PU covering embossed on it. Also, synthetic leather was brought up because it resembles natural leather. Genuine leather is of the most remarkable caliber, durable, and long-lasting. Faux leather, conversely, is synthetic but resembles genuine leather in appearance and feel [8]. Despite not being as robust as genuine leather, it is still used to create stylish, cost-effective items. Although the aesthetic behavior of this imitation leather and that of genuine leather are comparable, several additional qualities significantly differ, most notably the permeability to water vapor. The collagen fibers of genuine leather contain more hydrophilic groups than those of synthetic leather, which is the crucial distinction between the hygienic qualities of the two types of leather. Several exploratory studies on modifying synthetic leather have been carried out to deal with this problem. Combining various published data led researchers to conclude that the most effective modification method for synthetic leather is to increase its internal active groups. This method can be divided into two approaches based on synthetic leather components [9].

Innovation opportunities are increased when fiber-based materials are produced using biotechnological methods. In particular, fungus and bacterial yeast symbiosis are used to produce fibrous networks that resemble the fibrous structure of animal skin as freestanding materials or as a foundation for a coating layer. Bacteria like Acetobacter-xylinum produce micro-cellulosic fiber networks, whereas the mycelium fiber networks of fungi are composed of chitin, cellulose, and proteoglycans [10–12]. These mycelia multiply on organic waste [13]. Another approach involves using agricultural waste-derived items as filler materials instead of synthetic coatings made of polyvinyl chloride (PVC) or polyurethane (PUR), such as grain, apple pomace (Vegea®, Appleskin®), or milled cactus leaves (Desserto®). With this technique, fake leather's non-renewable material content is to be decreased. In Pinatex®, a third method for entirely replacing all elements derived from fossil fuels in a coated textile has been researched. In order to produce leather goods without using animals, this text combines convenience in the preparation process, affordability, and environmental friendliness. Orange peel scraps are used in this article as a raw material to create specimens with two different compositions. The differences between the specimens made and the SEM analysis were further investigated using an analysis of variance (ANOVA) related to mechanical properties.

2. Material and Method

The preparation of tools and materials, the creation of specimens, and the testing of specimens were the three main phases of this research. Table 1 displays the earliest stages of tool and material preparation.

Table 1. The equipment types and materials.

No	Materials	Equipment
1	Orange peel waste	Measuring cup
2	Dacron	Plastic basin
3	Gauze	Wood mold

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4	Alginate	Water spray
5	Glycerin	Electronic scale
6	Palm oil	Spatula
7	Calcium Chloride	Sieve 60 mesh
8	Cinnamon powder	Blender
9	Water	

The following steps comprise the specimen-making stage: Orange peel waste is typically discarded in the trash after being purchased from food and beverage merchants. The trash orange peel is thoroughly cleaned. In order to hasten the drying process by utilizing sunshine, the orange peel is also divided into tiny pieces. Following drying, the next step entails blending using a blender and filtering through a 60-mesh sieve to achieve the proper size for the following step.

This investigation combined basic materials such as orange peel waste, alginate, glycerin, coconut oil, and dacron/bandage cloth. Table 2 lists the mixture of basic materials used to produce synthetic leather.

Table 2. Material Composition.

Materials	Percentage
Dacron/bandage cloth	0,072
Alginate	0,162
Glycerin	0,449
Coconut Oil	0,067
Orange Peel Waste	0,233
Calcium chloride	0,018

A plastic bowl contains glycerin, alginate, palm oil, orange peel powder, cinnamon powder, and water. Then, use a mixer to combine the ingredients. Once combined, store the mixture uniformly away from direct sunlight. This storage procedure is used to eliminate bubbles that come out of the mixing process. Add the gauze or dacron to the mixture after 24 hours, then place it in a wooden mold after that. The exterior layer of synthetic leather is coated with a polyvinyl acetate (PVAc) polymer. The specimens are finally dried in the sun for around seven days to achieve a 15%–20% dryness level.

The finished specimens are tested as the final step. The test is conducted in a lab that has synthetic leather testing criteria. The strength differential between the two specimens, such as dacron and bandages, was also measured using this test. The ASTM D 2209-00 and ASTM D 4533-04 standards were used for the tests. Tensile strength, elongation, and tear test are all determined using these two accepted procedures. The Universal Testing Machine S/N 318 and the Digimatic Caliper S/N A15007746 were used for the tests.

A tensile test looks into the sample's mechanical behavior. Measurements were made at the Sucofindo Indonesia laboratory following ASTM D-2209-00 and ASTM D 4533-04 standards. For each sample, an average of ten tests are reported. The tensile modulus, tensile strength, and elongation-at-break (EB) were estimated from the stress-strain curve using the Tensile Lab software [14,15].

3. Result and discussion

3.1. Result and discussion

Bio-composite Leather Preparation

 doi:10.20944/preprints202402.0151.v1

Six samples (1A, 1B, 1C, 2A, 2B, and 2C) with different mixture components were initially prepared; rectangular and has a thickness of 2-3 mm. Figure 1 shows several colored samples. The surface texture is slightly rough, rigid, and flexible.

Figure 1. Several specimens of artificial leather made from orange peel waste.

a. Mechanical Test

In general, filler particle dispersion, interfacial adhesion, and component concentration are the main factors influencing the mechanical properties of bio-composites [19]. This work investigated and compared the influence of bio-fillers and polymer matrix (alginate and glycerin) on the mechanical properties of imitation leather bio-composites. The mechanical properties, including tensile strength, tear strength, and elongation at break, were tested for the two prepared bio-composite materials, and the results are presented in Table 3.

Table 3. Specimen test results.

Specimen	Thickness (mm)	Tensile Strength (N/cm2)	Elongation (%)	Tear Strength (N/cm)
1A	1.78 – 2.05	390-472	27.76 – 39.46	7.79 – 14.28
2A	1.21 – 1.45	220 - 246	36.2 – 49.50	6.39 – 6.94
1B	1.61 – 1.80	301 – 460	26.05 – 29.78	8.10 – 8.96
2B	1.24 – 1.34	128 – 153	50.03 – 51.58	1.46 – 2.36
1C	2.61 – 2.99	275.04 – 343.74	51.08 – 67.28	7.44 – 8.42
2C	1.99 – 2.26	179.03 – 181.85	45.12 – 48.31	4.26 – 4.57

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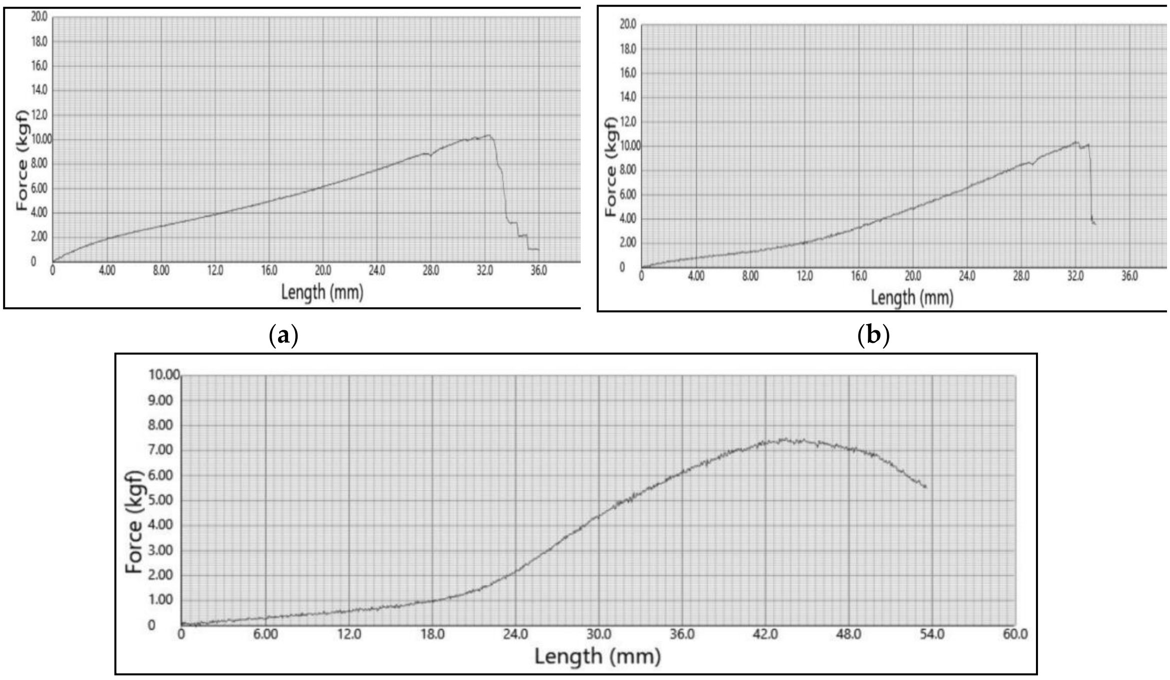
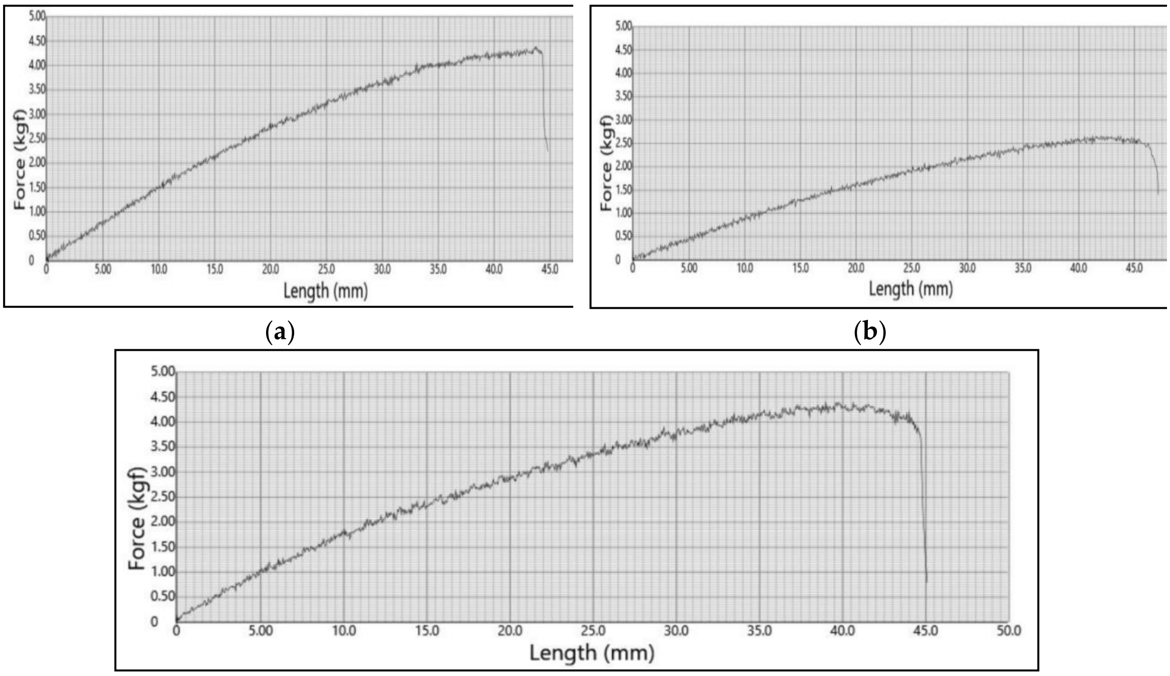


(c)

Figure 2. Test specimens of Pomelo (a), Sunkist Oranges (b), and Sweet Oranges (c) using bandage reinforcement.



(c)

Figure 3. Test specimens of Balinese Oranges (a), Sunkist Oranges (b), and Sweet Oranges (c) using Dacron cloth reinforcement.

Information related to the mechanical test results was obtained based on the six types of specimens. Furthermore, each specimen's average thickness varies, ranging from 1.24 to 2.99 mm. The process of making imitation leather still uses straightforward equipment. The highest thickness in specimen 1 C is around 2.99 mm, and specimen 2A is the specimen with the thinnest thickness, around 1.21 mm. Furthermore, from the test results, information was obtained regarding the tensile strength of each test specimen, where the highest tensile strength value was around 460 N/cm2, and

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the lowest tensile strength value for specimen 2 B was 128 N/cm2. This mechanical test also revealed that the lowest elongation occurred at 26.05% in specimen 1B, and the highest elongation, 1C, was 67.28%. In addition, information obtained in the tear test was the highest value of 8.96 N/cm on specimen B and the lowest value of 1.46 N/cm on specimen 2B. According to Prithivirajan et al.'s work, adding stiff particles to the matrix causes stress concentration zones, leading to interfacial debonding under stress and even sample disintegration[16]. Furthermore, improved matrices-to-matrices interactions and homogeneous polymer dispersion produce favorable mechanical properties [17].

Based on the tensile test results it shows that the highest value from the tensile test is around 472 N/cm2 and the lowest is around 128 N/cm2. In addition, several samples show that the tensile strength meets the Indonesian standard SNI 1294:2009, namely around 180 N/cm2. However, only sample 2B does not meet the SNI 1294:2009 standard because the value is around 128-153 N/cm2. Furthermore, when viewed from an ISO 3376 perspective, the use of plant fibers as artificial leather material has a tensile strength value of around 4.5 N/mm2. Thus, only sample 2B does not meet the ISO 3376 standard because it has a value of around 180 N/cm2. ISO 3377-1 shows that the standard value for plant fiber as an artificial leather material has a tear strength value of around 31 N/mm. Thus, the test results on material using orange peel waste also show that specimen 2B does not meet the ISO 3377-1 standard because it has the highest value of around 23.6 N/mm and the lowest value of around 14.6 N/mm.

b. Statistic analysis

In order to determine the level of differences in mechanical properties of each artificial leather specimen, a statistical analysis test was carried out using one-way ANOVA. Furthermore, this statistical test will also analyze differences in each artificial leather specimen's thickness, tensile strength, elongation, and tear strength. Based on The statistical analysis results on all artificial leather specimens it is shown in Table 4.

Table 4. Recapitulation of ANOVA results for Specimen 1A.

Characteristics	*Source of Variation*	*SS*	*df*	*MS*	*F_{Count}*	*P-value*	*F_{Table}*	*Conclusion*
Material thickness and tensile strength	Between Groups	2755319	1	2755319	7133,766	2,05E-62	4,006873	Material thickness greatly influences Tensile Strength (F count > F Table)
	Within Groups	22401,71	58	386,2363				
	Total	2777721	59					
Material thickness with elongation	Between Groups	15010,02	1	15010,02	2392,825	7,46E-49	4,006873	Material thickness greatly influences Elongation (F count > F Table)
	Within Groups	363,8298	58	6,272927				
	Total	15373,85	59					

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Tensile strength with elongation	Between Groups	2363599	1	2363599	6021,876	2,67E-60	4,006873	Tensile strength affects elongation (F count > F table)
	Within Groups	22765,12	58	392,5021				
	Total	2386364	59					
Material thickness and tear strength	Between Groups	1187,349	1	1187,349	397,8163	1,21E-27	4,006873	Material thickness affects tear strength (F count > F table)
	Within Groups	173,1107	58	2,984667				
	Total	1360,46	59					

Table 5. Recapitulation of ANOVA results for Specimen 2A.

Characteristics	*Source of Variation*	*SS*	*df*	*MS*	F_{Count}	*P-value*	F_{Table}	*Conclusion*
Material thickness and tensile strength	Between Groups	791500,3	1	791500,3	14760,84	1,6E-71	4,006873	Material thickness greatly influences Tensile Strength (F count > F Table)
	Within Groups	3110,055	58	53,62164				
	Total	794610,3	59					
Material thickness with elongation	Between Groups	26413,4	1	26413,4	3455,8	2,16E-53	4,006873	Material thickness greatly influences Elongation (F count > F Table)
	Within Groups	443,3062	58	7,64321				
	Total	26856,71	59					
Tensile strength with elongation	Between Groups	528734	1	528734	8631,216	8,49E-65	4,006873	Tensile strength affects elongation (F
	Within Groups	3552,984	58	61,25835				

	Total	532287	59					count > F table)
Material thickness and tear strength	Between Groups	399,4872	1	399,4872	27094,44	3,78E-79	4,006873	Material thickness affects tear strength (F count > F table)
	Within Groups	0,855167	58	0,014744				
	Total	400,3424	59					

Table 6. Recapitulation of ANOVA results for Specimen 1B.

Characteristics	*Source of Variation*	*SS*	*df*	*MS*	*F*F_{Count}	*P-value*	F_{Table}	*Conclusion*
Material thickness and tensile strength	Between Groups	2156965	1	2156965	1930,058	3,23E-46	4,006873	Material thickness greatly influences Tensile Strength (F count > F Table)
	Within Groups	64818,77	58	1117,565				
	Total	2221784	59					
Material thickness with elongation	Between Groups	10396,93	1	10396,93	18187,82	3,84E-74	4,006873	Material thickness greatly influences Elongation (F count > F Table)
	Within Groups	33,15525	58	0,571642				
	Total	10430,08	59					
Tensile strength with elongation	Between Groups	1867857	1	1867857	1670,513	1,87E-44	4,006873	Tensile strength affects elongation (F count > F table)
	Within Groups	64851,78	58	1118,134				
	Total	1932709	59					
Material thickness and tear strength	Between Groups	676,7713	1	676,7713	13540,27	1,94E-70	4,006873	Material thickness affects tear
	Within Groups	2,898963	58	0,049982				

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								strength
	Total	679,670 3	5 9					(F count > F table)

Table 7. Recapitulation of ANOVA results for Specimen 2B.

Characteristics	*Source of Variation*	*SS*	*df*	*MS*	*F_{Count}*	*P-value*	*F_{Table}*	*Conclusion*
Material thickness and tensile strength	Between Groups	304323, 1	1	304323, 1	10310,5 4	5,05E-67	4,00687 3	Material thickness greatly influences Tensile Strength (F count > F Table)
	Within Groups	1711,91 2	5 8	29,5157 3				
	Total	306035	5 9					
Material thickness with elongation	Between Groups	37008,1 2	1	37008,1 2	291173, 1	5E-109	4,00687 3	Material thickness greatly influences Elongation (F count > F Table)
	Within Groups	7,37180 3	5 8	0,1271				
	Total	37015,5	5 9					
Tensile strength with elongation	Between Groups	129082	1	129082	4354,81	2,91E-56	4,00687 3	Tensile strength affects elongation (F count > F table)
	Within Groups	1719,19 3	5 8	29,6412 6				
	Total	130801, 2	5 9					
Material thickness and tear strength	Between Groups	676,771 3	1	676,771 3	13540,2 7	1,94E-70	4,00687 3	Material thickness affects tear strength (F count > F table)
	Within Groups	2,89896 3	5 8	0,04998 2				
	Total	679,670 3	5 9					

Table 8. Recapitulation of ANOVA results for Specimen 1C.

Characteristics	*Source of Variation*	*SS*	*df*	*MS*	F_{Count}	*P-value*	F_{Table}	*Conclusion*
Material thickness and tensile strength	Between Groups	1418183	1	1418183	5427,793	5,27E-59	4,006873	Material thickness greatly influences Tensile Strength (F count > F Table)
	Within Groups	15154,34	58	261,2817				
	Total	1433337	59					
Material thickness with elongation	Between Groups	47508,58	1	47508,58	4289,939	4,47E-56	4,006873	Material thickness greatly influences Elongation (F count > F Table)
	Within Groups	642,3163	58	11,07442				
	Total	48150,9	59					
Tensile strength with elongation	Between Groups	267540,6	1	267540,6	341327,8	4,9E-111	4,006873	Tensile strength affects elongation (F count > F table)
	Within Groups	45,46175	58	0,783823				
	Total	267586,1	59					
Material thickness and tear strength	Between Groups	436,2372	1	436,2372	7232,814	2,95E-64	4,001191	Material thickness affects tear strength (F count > F table)
	Within Groups	3,618817	60	0,060314				
	Total	439,856	61					

Table 9. Recapitulation of ANOVA results for Specimen 2C.

Characteristics	*Source of Variation*	*SS*	*df*	*MS*	F_{Count}	*P-value*	F_{Table}	*Conclusion*
Material thickness	Between Groups	476639,6	1	476639,6	1057138	2,9E-125	4,006873	Material thickness

and tensile strength	Within Groups	26,15089	58	0,450877				greatly influences Tensile Strength (F count > F Table)
	Total	476665,8	59					
Material thickness with elongation	Between Groups	29980,1	1	29980,1	88094,06	5,57E-94	4,006873	Material thickness greatly influences Elongation (F count > F Table)
	Within Groups	19,73852	58	0,340319				
	Total	29999,84	59					
Tensile strength with elongation	Between Groups	267540,6	1	267540,6	341327,8	4,9E-111	4,006873	Tensile strength affects elongation (F count > F table)
	Within Groups	45,46175	58	0,783823				
	Total	267586,1	59					
Material thickness and tear strength	Between Groups	79,74025	1	79,74025	10785,7	1,38E-67	4,006873	Material thickness affects tear strength (F count > F table)
	Within Groups	0,428802	58	0,007393				
	Total	80,16905	59					

c. Scanning Electron Microscope (SEM) test

This paper also explored the use of scanning electron microscope (SEM) testing to see the morphology and topography of the samples. It is also used to determine the distribution of elements (mapping) in the sample. The results of SEM testing are shown in Figure 4 and Figure 5.

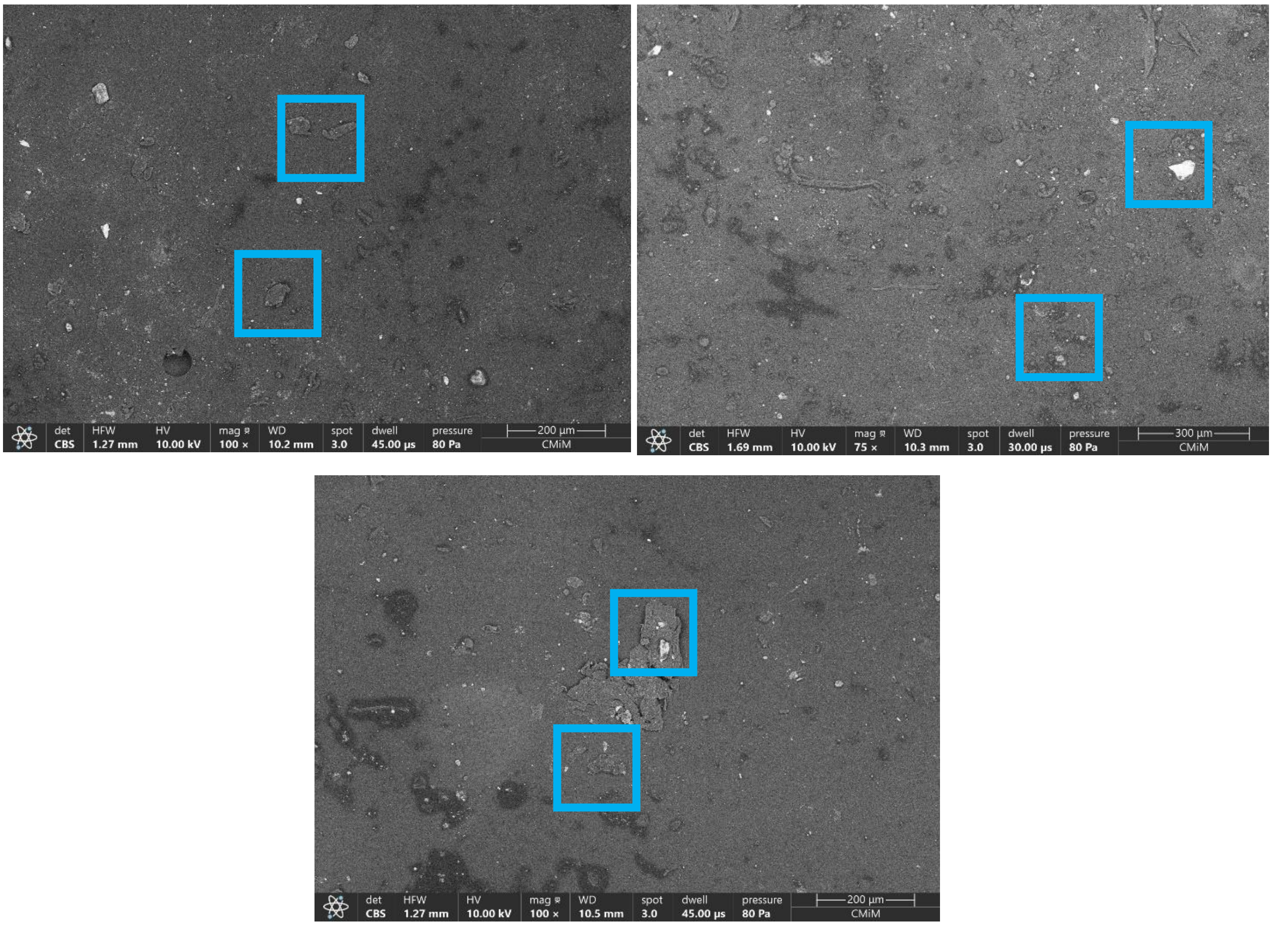

Figure 4. SEM testing on artificial leather material made from Pomelo, Sunkist, and Sweet orange leather with bandage reinforcement.

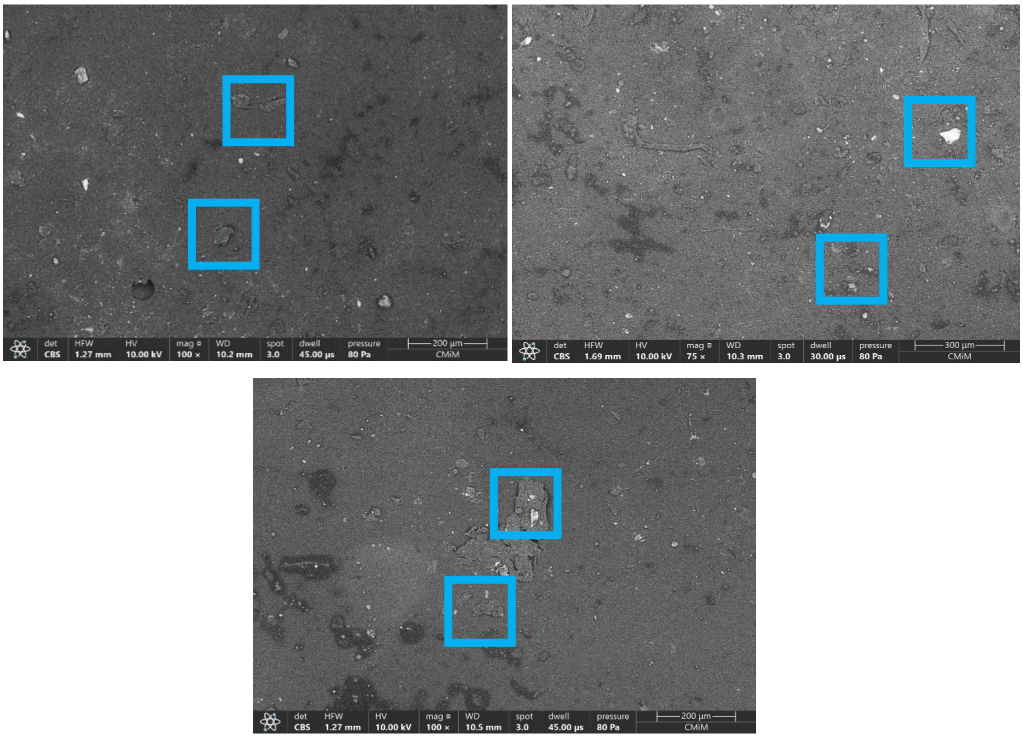

Figure 5. SEM testing on artificial leather material made from Pomelo, Sunkist, and Sweet orange with Dacron fabric reinforcement.

To determine the morphological structure of artificial leather made from orange peel waste, analysis was carried out using SEM, as shown in Figure 4 and Figure 5. Furthermore, the test results showed the morphology of artificial leather at magnifications of 600 and 2000 times. Furthermore, the test results also provide information that there are several lumps on the surface of the test specimen. We assume that the orange peel powder waste particles are not uniform and that the alginate content must still be mixed perfectly. Furthermore, the test material was characterized by several lumps that were slightly dark in color. Apart from that, the SEM test results also show that certain surfaces provide an even image. Therefore, the composition of all raw materials is mixed well and blended with the bandage and dacron cloth materials.

3.2. Discussion

Genuine leather can be distinguished from synthetic leather by its inherent characteristics. Quality and durability are the primary distinctions between genuine and imitation leather. Because imitation and genuine protected leather might have similar appearances, it can be challenging to distinguish between the two. There are a few methods available to distinguish genuine leather from imitation. Faux leather was once considered a very cheap imitation of natural leather. Only genuine leather goods qualify as high-end, luxurious items. Luxury apparel labels would never use synthetic ones. However, the quality and functionality of imitation leather have significantly increased as a result of synthetic leather's advanced development in recent years. Because of its remarkably leather-like texture and appearance, it is becoming increasingly popular in the clothing business [18]. Because it is less expensive, more flexible, and does not require any actual animal hide, artificial leather is frequently used as a replacement for genuine leather in numerous applications. The principal uses for this well-liked material include shoes, furniture, cars, clothing, and bags. A base fabric coated with or laminated to a polymeric substance like polyvinyl chloride (PVC) or polyurethane (PU) makes up the material [19]. The foundation cloth that strengthens the polymeric film against mechanical damage might be made of woven, knitted, or non-woven materials. The quality of products made with artificial leather depends on several factors, including the material's handling and other physical characteristics. People are more inclined to wear them because various clothes products are available today. Future research in the clothing business will focus heavily on increasing the value of this leather. Before moving on, it is essential to acquire a fundamental understanding of synthetic leather via natural to assess the likelihood of replacing genuine leather with synthetic leather [20]. The applications and distinctions between genuine and synthetic leather through natural means help compare the characteristics of the two varieties of leather. A primary concern that must be taken into account is the environmental and animal rights considerations. One of the main issues in many businesses these days, including the garment industry, is the influence on the environment. An increasing number of designers demonstrate their environmental consciousness by utilizing eco-friendly materials. If we were to go deeper into the origins and manufacturing process of genuine leather, it would no longer be considered natural. Thus, imitation leather might be a preferable substitute [20,21].

In order to create synthetic leather, PU resin is typically applied over a base fabric, which is typically knit or woven from synthetic fibers, creating open cells to allow for air permeability. A polymer compound with a urethane bond (-NHCOO-), PU has a chemical structure in which two segments exist simultaneously in a molecule: a soft segment created by the reaction of diisocyanate and polymeric polyol and a hard segment formed by the reaction of diisocyanate and chain extender. PU has a scarce combination of tenacity and elasticity due to its molecular structure [22,23]. Its physical characteristics are highly contingent upon the kind and makeup of the monomer utilized as the binder. Stated differently, the sensory values of a porous surface layer, such as its appearance and tactile perception, as well as properties like water resistance, bend resistance, surface strength, and moisture transpiration, are primarily determined by the processing method and structure of the layer [22]. In addition, adding more collagen to synthetic leather produces more micropores than ordinary synthetic leather. Additionally, the increased collagen concentration increases bending and

 doi:10.20944/preprints202402.0151.v1

compression, making the leather stiffer while reducing geometrical roughness and coefficient of friction, giving the surface a softer appearance.

The study by Roh examined the mechanical characteristics and tastes of synthetic and natural leathers [10]. The mechanical characteristics of the leathers that affected their preferences were used to categorize them. The KES-FB system was utilized to measure the mechanical qualities of the leather, and an expert poll was carried out to assess the preference for leather. The mechanical properties of leathers vary based on their structural makeup and method of manufacture. Moreover, distinctions between the mechanical characteristics of synthetic and natural leather were noted. Preferences for hands and bags were connected to the mechanical characteristics of the leathers. As a result, three clusters were identified from the leather. Certain types of leather were better suited for bags than hands, and vice versa for palms and hands. Therefore, different development tactics are required depending on the type of leather. In contrast to artificial leather, which should be light and have better tensile resilience, natural leather for bags should be light and have strong compression elasticity in addition to its current mechanical qualities.

The biomaterial has exceptional flexibility and tensile strength (maximum: 247.21 16.52 N); it can be folded more than 100 times at the same spot without breaking or cracking [24]. The bio-textile experienced only minor water interaction, as indicated by the 83.96-degree water contact angle. The findings of this study show that British Columbia can produce innovative, long-lasting, vegan, waterproof fashion items. Additionally, Bryszewska highlighted the impact of adding apple powder to the SCOBY culture media on the mechanical characteristics of the bacterial cellulose produced [25]. The final product developed new mechanical properties that are beneficial in strength. The apple powder coating appeared consistent when viewed at a microscopic scale. From 10% to 60% of apple powder was applied to the cellulose surface in various amounts, and it was discovered that the variation with 40% of this powder had the best mechanical strength. Additionally, the material's use as a card folder demonstrated its durability and ability to keep its valuable properties for at least a month.

New materials are being developed and proposed as potential leather substitutes [13,26]. Additionally, these materials are referred to as "trendy alternatives." Three of these substitute materials are chosen for the report, and the material composition and a few of its properties are mentioned. Pinatex, Desserto, and so-called mushroom leather are some of these materials. Pinatex is a composite material of plant fibres derived from pineapple leaves and PLA, a biopolymer. The PLA, which is included in this material at a ratio of 20%, holds the fibres together and creates a non-woven structure [26]. Desserto is marketed as vegan leather made from cactus as well. The easiest way to characterize this material is as laminate, made of polyester fabric with a modified polyurethane coating. At least 65% of the biobased particles that fill the polyurethane substance are made from cacti plants. Without additional coating or textile backing, mushroom leather is a naturally occurring substance[27–29]. Unlike Pinatex and Desserto, which are materials, different providers provide a range of goods that fall into this category for mushroom leather [26]. To support general information on various alternative materials due to their composition, as well as those working in material analytics who must identify new materials, the material composition of those materials is examined using a variety of methodologies and discussed.

4. Conclusion

This experimental research aims to develop new formulations for environmentally friendly artificial leather products. To make bio-composite materials, cellulose biomass from orange peel waste is mixed with naturally degraded polyester polymer. This research analyzes the potential for utilizing orange peel waste to make artificial leather. The orange peel used in making artificial leather consists of Pomelo, Sunkist, and sweet orange. Apart from that, making artificial leather also uses two types of fabric as reinforcement, namely bandage cloth and dacron cloth. To achieve this, we created biomaterial samples that meet the experimental requirements of ASTM D 2209-00 and ASTM D 4533-04. This research also used several parameters, such as tensile strength, elongation, tear strength, and SEM testing. Laboratory test results show significant differences in the mechanical properties of each type of artificial leather based on the orange peel material characteristics and the reinforcing fabric. Tensile strength testing showed that specimen 1 A gave the best results. Moreover, the best elongation test was on specimen 1 C, and the best tear strength test was on specimen 1 A. Furthermore, the test results also show that composition 2B still does not meet the standards of SNI 1294:2009 and ISO 3376 for tensile strength and ISO 3377-1 for tear strength. In addition, SEM testing showed that the surface was not perfectly even and needed further improvement in the process. They were mixing the materials. The results of this experimental study can be expanded and utilized as a basic framework for developing bio-composites for artificial skin in the future.

Credit authorship contribution statement: Dino Rimantho: Conceptualization, method, investigation, writing, editing, supervision, review. **Laela Chaerani**: Method investigation, data investigation. **Anggina Sandy,** Investigation, editing review.

Funding: This research received financial support from the Ministry of Education, Culture and Technological Research through research grant funds with Main Contract Number 179/E5/PG.02.00/PL/2023 and Derivative Agreement/Contract Number 1427/LL3/AL.04/2023

Declaration of Competing Interest: The authors state that none of the work described in this publication appears to have been influenced by any known competing financial interests or personal ties.

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