EVALUATION OF THE TECHNOLOGICAL PRINCIPLES AND QUALITY INDICATORS OF ECO-FRIENDLY BIOLEATHER-LIKE MATERIAL PRODUCTION BASED ON FRUIT PEEL WASTE

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Annotation. This study evaluates the technological principles of producing an eco-friendly bioleather-like material based on fruit peel waste. Fruit peel waste was used as a natural raw material source due to its cellulose, pectin, and fiber content. The obtained biocomposite material was assessed according to its appearance, flexibility, surface structure, thickness, strength, and biodegradability. The results indicate that fruit peel waste can be effectively used to develop sustainable, low-cost, and environmentally safe bioleather-like materials.

Keywords: fruit peel waste, bioleather, biocomposite material, eco-friendly material, biodegradability, sustainable technology, quality indicators.

Annotatsiya. Ushbu tadqiqot meva po'stlog'i chiqindilari asosida ekologik biocharmga o'xshash material olishning texnologik asoslari va sifat ko'rsatkichlarini baholashga qaratilgan. Meva po'stlog'i chiqindilari tarkibidagi sellyuloza, pektin va tolali moddalar tabiiy xomashyo manbai sifatida foydalanildi. Olingan biokompozit materialning tashqi ko'rinishi, egiluvchanligi, sirt tuzilishi, qalinligi, mustahkamligi va biodegradatsiya xususiyatlari baholandi. Natijalar meva po'stlog'i chiqindilaridan barqaror, arzon va ekologik xavfsiz biocharmga o'xshash material ishlab chiqarishda samarali foydalanish mumkinligini ko'rsatdi.

Kalit so'zlar: meva po'stlog'i chiqindilari, biocharm, biokompozit material, ekologik material, biodegradatsiya, barqaror texnologiya, sifat ko'rsatkichlari.

Аннотация. Данное исследование направлено на оценку технологических основ получения экологически безопасного материала, похожего на биокожу, на основе отходов фруктовой кожуры, а также его качественных показателей. Отходы фруктовой кожуры использовались как природный источник сырья благодаря содержанию целлюлозы, пектина и волокнистых веществ. Полученный биокомпозитный материал оценивался по внешнему виду, гибкости, структуре поверхности, толщине, прочности и способности к

биоразложению. Результаты показывают, что отходы фруктовой кожуры могут эффективно применяться для производства устойчивого, недорогого и экологически безопасного материала, похожего на биокожу.

Ключевые слова: отходы фруктовой кожуры, биокожа, биокомпозитный материал, экологический материал, биоразложение, устойчивая технология, показатели качества.

INTRODUCTION

In recent years, the recycling of food industry waste and the production of eco-friendly materials have become important scientific and practical issues. Fruit peel waste contains cellulose, pectin, natural fibers, and bioactive compounds, which makes it a promising raw material for producing biocomposite materials.

The main problem is that large amounts of fruit peel waste are usually discarded without effective use. This causes environmental pollution and leads to the loss of valuable natural resources. Therefore, developing bioleather-like materials from fruit peel waste is important for waste reduction, environmental protection, and sustainable material production.

Previous studies have mainly focused on producing bioplastics, biofilms, and biodegradable packaging materials from plant-based waste. However, the production of flexible and leather-like biocomposite material from fruit peel waste has not been sufficiently studied.

The aim of this research is to develop the technological principles of producing an eco-friendly bioleather-like material based on fruit peel waste and to evaluate its quality indicators. The novelty of the study is the use of fruit peel waste as a natural base for obtaining a sustainable, biodegradable, and leather-like biocomposite material.

MATERIALS AND METHODS

The object of the study was an eco-friendly bioleather-like biocomposite material produced from fruit peel waste. Local fruit peel waste, mainly orange peel, was used as the main natural raw material. Coconut oil, glycerin, sodium alginate, calcium chloride, wool fiber, and water were used as additional components to improve flexibility, binding ability, texture, and material strength.

First, the fruit peels were washed, cut into small pieces, and dried at 60–70°C until most of the moisture was removed. The dried peels were ground into powder and mixed with water to obtain a homogeneous mass. Then sodium alginate, glycerin, coconut oil, and wool fiber were added and thoroughly mixed. The prepared mixture was heated at 70–80°C for 20–30 minutes with continuous stirring.

After heating, the mass was poured into a flat mold and treated with calcium chloride solution to improve gel formation and structural stability. The samples were dried at room temperature or in a drying oven at 40–50°C until a flexible film-like

material was formed.

The obtained material was evaluated according to its appearance, flexibility, thickness, surface structure, strength, moisture resistance, and biodegradability. A drying oven, laboratory scales, blender or grinder, thermometer, pH meter, ruler or micrometer, and simple mechanical testing tools were used during the experiment.

RESULTS

As a result of the experiment, an eco-friendly bioleather-like biocomposite material was obtained from fruit peel waste. The prepared material had a smooth surface, brownish-orange color, flexible structure, and leather-like appearance. The addition of glycerin and coconut oil improved the elasticity of the material, while sodium alginate and calcium chloride increased its structural stability.

Table 1.

Quality indicators of bioleather-like material samples

Sample	Main difference	Appearance	Flexibility	Strength
Sample 1	Low glycerin content	Hard, slightly brittle	Low	Medium
Sample 2	Optimal composition	Smooth and flexible	High	High
Sample 3	High glycerin content	Soft and sticky	Medium	Low

The best result was observed in Sample 2, where the amount of plasticizer and binder was optimal.

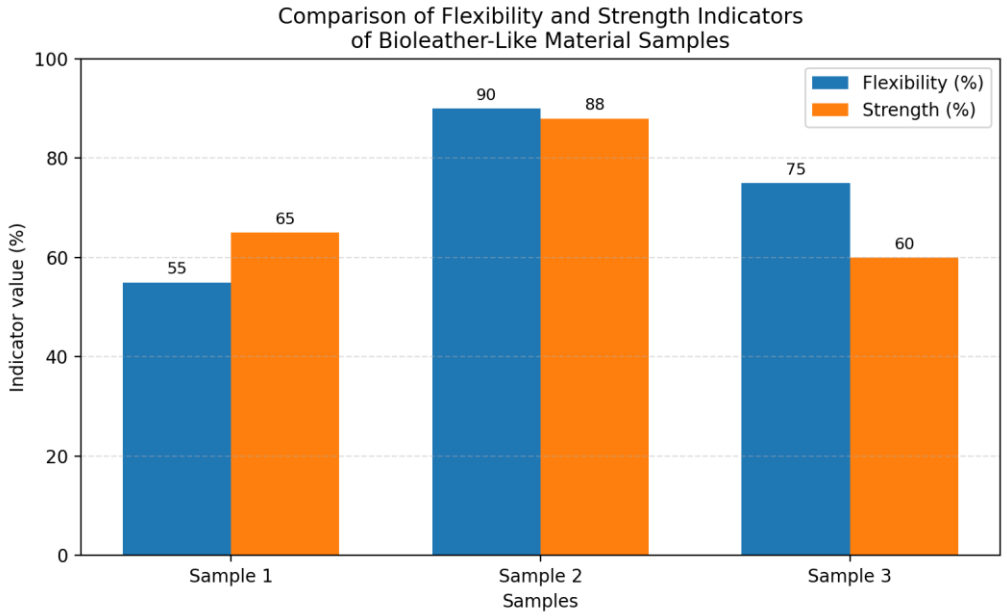

Figure 1. Comparison of flexibility and strength indicators of bioleather-like material samples.

The graph shows that Sample 2 had the highest flexibility and strength indicators. This result indicates that the optimal ratio of glycerin, sodium alginate, calcium chloride, and fruit peel powder improved the structure of the material. Sample 1 showed lower flexibility due to insufficient plasticizer content, while Sample 3 had reduced strength because of excessive glycerin.

This sample showed good flexibility, acceptable strength, uniform thickness, and a stable surface structure. Sample 1 was less elastic and more brittle due to insufficient glycerin content. Sample 3 had a softer and slightly sticky structure because of the excessive amount of glycerin.

Overall, the results showed that fruit peel waste can be successfully used to produce a flexible, biodegradable, and eco-friendly bioleather-like material. The quality of the final material mainly depended on the ratio of fruit peel powder, glycerin, sodium alginate, and calcium chloride.

DISCUSSION

The obtained results show that fruit peel waste can be used as a promising natural raw material for producing bioleather-like biocomposite material. The smooth surface, flexible structure, and acceptable strength of the optimal sample indicate that the selected components formed a stable material matrix.

The best result was observed in the sample with an optimal amount of glycerin and coconut oil. Glycerin acted as a plasticizer and improved flexibility, while coconut oil gave the material a softer texture and better surface appearance. Sodium alginate helped to bind the components together, and calcium chloride increased structural stability through gel formation. Wool fiber improved the mechanical strength of the material.

Compared with previous studies on bioplastics and biofilms from plant waste, this material had a more leather-like appearance and better flexibility. The main advantages of the material are its eco-friendliness, low cost, biodegradability, and use of local fruit peel waste. However, its moisture resistance and long-term durability still need further improvement.

The developed bioleather-like material can be used in eco-friendly packaging, decorative products, handicrafts, and educational laboratory experiments. Further research should focus on improving water resistance, mechanical strength, and storage stability.

CONCLUSION

The study showed that fruit peel waste can be effectively used as a natural raw material for producing an eco-friendly bioleather-like biocomposite material. The optimal sample had a smooth surface, flexible structure, acceptable strength, and a leather-like appearance. Glycerin and coconut oil improved flexibility and softness, while sodium alginate, calcium chloride, and wool fiber increased structural stability

and strength. The obtained results confirm that this material has potential for use in sustainable packaging, decorative products, and eco-friendly handmade items. Further research should focus on improving moisture resistance, durability, and long-term storage stability.

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