DEVELOPMENT OF A BIOCOMPOSITE MATERIAL WITH BIOLEATHER PROPERTIES BASED ON LOCAL FRUIT PEEL WASTE AND EVALUATION OF ITS PHYSICOTECHNOLOGICAL PROPERTIES

***S.N.Obloberdiyev*[1], *G.Sh.Korabekova*[2], *F.Sh.G'ulomova*[3], *M.J.Bekmurodova*[3], *Sh.E.Ulashova*[3], *Z.A.Madusmonova*[3]**

[1]Acting Associate Professor, Tashkent Institute of Chemical Technology, Yangiyer Branch, Yangiyer, Uzbekistan

[2]Master's student, Tashkent Institute of Chemical Technology, Yangiyer Branch, Yangiyer, Uzbekistan

[3]Bachelor's student, Tashkent Institute of Chemical Technology, Yangiyer Branch, Yangiyer, Uzbekistan

Abstract. This article studies the technology of obtaining a biocomposite material with bio-leather properties based on local fruit peel waste. In the study, samples were prepared using fruit peel powder, natural biopolymers and plasticizers, and their appearance, flexibility, density, water resistance and surface structure were evaluated. The results showed that fruit peel waste can be used to obtain an environmentally safe biocomposite material similar to bio-leather.

Keywords: fruit peel, bio-leather, biocomposite, eco-friendly material, waste recycling, flexibility, physicotechnological properties.

Аннотация. В данной статье изучена технология получения биокомпозитного материала со свойствами биокожи на основе местных отходов кожуры фруктов. В исследовании образцы были получены с использованием порошка фруктовой кожуры, природных биополимеров и пластификаторов, а также оценены их внешний вид, гибкость, плотность, водостойкость и структура поверхности. Результаты показали возможность получения экологически безопасного биокомпозитного материала, похожего на биокожу, из отходов фруктовой кожуры.

Ключевые слова: фруктовая кожура, биокожа, биокомпозит, экологический материал, переработка отходов, гибкость, физико-технологические свойства.

Annotatsiya. Ushbu maqolada mahalliy meva po'stlog'i chiqindilari asosida biocharm xususiyatiga ega biokompozit material olish texnologiyasi o'rganildi. Tadqiqotda meva po'stlog'i kukuni, tabiiy biopolimerlar va plastifikatorlar asosida namuna tayyorlanib, uning tashqi ko'rinishi, egiluvchanligi, zichligi, suvga chidamliligi va sirt tuzilishi baholandi. Natijalar meva po'stlog'i chiqindilaridan ekologik xavfsiz, biocharmga o'xshash biokompozit material olish mumkinligini ko'rsatdi.

Kalit so‘zlar: meva po‘stlog‘i, biocharm, biokompozit, ekologik material, chiqindilarni qayta ishlash, egiluvchanlik, fizik-texnologik xossalar.

INTRODUCTION

In recent years, recycling food industry waste into environmentally safe materials has become an important issue. Local fruit peel waste contains cellulose, pectin, natural fibers, and bioactive compounds, making it a suitable raw material for biocomposite production.

Fruit peel waste is often discarded without processing, causing environmental pollution and loss of valuable resources. Therefore, producing bioleather-like materials from such waste is important from both ecological and economic perspectives.

Although previous studies have explored biofilms, bioplastics, and packaging materials from fruit and vegetable waste, the production of flexible and dense bioleather-like biocomposites from local fruit peel waste remains insufficiently studied.

The aim of this study is to develop a biocomposite material with bioleather properties based on local fruit peel waste and evaluate its physicotechnological properties. The novelty lies in combining fruit peel waste with natural biopolymers and plasticizers and assessing the material’s flexibility, density, surface structure, and water resistance.

MATERIALS AND METHODS

A biocomposite material with bioleather properties prepared from local fruit peel waste was selected as the object of the study. Orange, pomegranate, or other local fruit peels were used as the main raw materials. Sodium alginate, gelatin or starch, glycerin, calcium chloride solution, and drinking water were used as additional components.

First, the fruit peels were washed, cut into small pieces, and dried at a temperature of 50–60 °C. The dried peels were then ground into powder using a grinder. After that, a biopolymer solution was prepared, and fruit peel powder and glycerin were added to it. The mixture was stirred at 40–50 °C until a homogeneous mass was obtained.

The prepared mass was poured into a flat mold as a thin layer and dried at 35–45 °C. The dried sample was treated with calcium chloride solution to improve the density and water resistance of the material. Then, the sample was kept at room temperature and prepared for further analysis.

During the study, the appearance, color, surface structure, thickness, flexibility, density, strength, and water resistance of the obtained biocomposite material were evaluated. An electronic balance, thermometer, drying oven, grinder, laboratory glassware, stirrer, mold, and measuring instruments were used in the experiment.

RESULTS

As a result of the experiment, a biocomposite material similar to bioleather was obtained from local fruit peel waste. The prepared material was brownish-yellow in color, had a smooth surface, and formed as a flexible thin layer. Changes in the amount of fruit peel powder affected the color, density, flexibility, and strength of the material.

In the study, samples containing different amounts of fruit peel powder were prepared, and their physicotechnological properties were compared. As the amount of powder increased, the density and water resistance of the material improved. However, when an excessive amount was added, flexibility decreased and brittleness was observed.

Table 1

Effect of fruit peel powder content on the properties of the biocomposite material

Indicators	Low-content sample	Optimal-composition sample	High-content sample
Fruit peel powder, %	5	10	15
Thickness, mm	0.45	0.60	0.75
Density condition	Medium	Dense	Very dense
Flexibility	Good	Very good	Lower
Strength	Medium	High	Hard, brittle
Water resistance, min	12	18	20
Appearance	Light-colored	Similar to bioleather	Darker, rougher
Overall score, points	3.8	4.7	4.1

According to the table results, the sample containing 10% fruit peel powder showed the most optimal result. In this sample, the material thickness was 0.60 mm, water resistance was 18 minutes, and the overall score was 4.7 points. The surface structure of the material was uniform, its flexibility was high, and its appearance was close to that of bioleather.

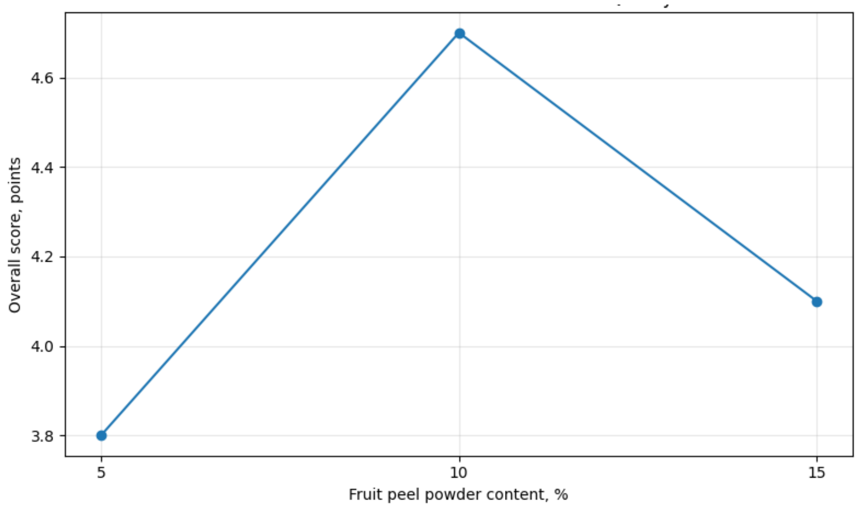

Figure 1. Effect of fruit peel powder content on the overall quality score of the biocomposite material

As can be seen from the graph, when the amount of fruit peel powder increased from 5% to 10%, the overall quality score of the biocomposite material increased from 3.8 to 4.7 points. However, when the powder content reached 15%, the overall score decreased to 4.1 points. This indicates that 10% fruit peel powder is the most suitable amount for improving the flexibility, density, and appearance of the material.

In the sample containing 5% powder, the material had a lighter color and relatively lower density. This can be explained by the insufficient effect of natural fibers and pigments present in the fruit peel. In the sample containing 15% powder, although the material became denser and more water-resistant, its flexibility decreased, and hardness and brittleness were observed.

In general, the use of fruit peel powder at a concentration of 10% was evaluated as the most optimal composition for providing the biocomposite material with flexibility, density, strength, and a bioleather-like appearance.

DISCUSSION

The obtained results showed that local fruit peel waste is a suitable raw material for producing a biocomposite material similar to bioleather. The amount of fruit peel powder directly affected the color, surface structure, density, flexibility, and water resistance of the material.

In the sample containing 5% powder, the material had a relatively light color and medium density. This can be explained by the low amount of natural fibers and pigments. In the sample containing 10% powder, the material obtained a bioleather-like appearance, good flexibility, and high strength. Therefore, this composition was evaluated as the most optimal.

In the sample containing 15% powder, the density and water resistance slightly increased, but flexibility decreased and brittleness was observed. This is related to the fact that an excessive amount of powder may interfere with the uniform formation of the biopolymer matrix.

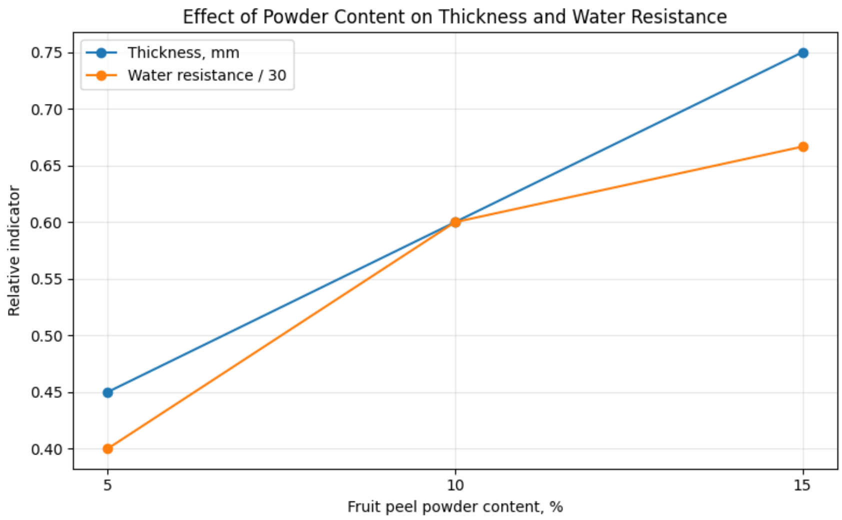

Figure 2. Effect of fruit peel powder content on material thickness and water resistance

According to the graph results, as the amount of fruit peel powder increased, the thickness and water resistance of the material also increased. However, when 15% powder was added, although the material became denser, its flexibility decreased and brittleness was observed. Therefore, 10% fruit peel powder was evaluated as the most optimal composition in terms of overall quality indicators.

The biopolymers in the composition formed the main binding structure of the material. Glycerin increased flexibility, while calcium chloride improved density and water resistance. Fruit peel powder contributed to the formation of natural color, fibrous structure, and a bioleather-like appearance.

Previous studies have reported the possibility of producing biofilms, bioplastics, and packaging materials from fruit and vegetable waste. The results of this study also confirm the possibility of obtaining an environmentally friendly biocomposite material based on waste.

The advantage of the study is the use of local and inexpensive raw materials, the simplicity of the technology, and the possibility of obtaining an environmentally safe material. The limitation is the need to further improve the water resistance and mechanical strength of the material. From a practical point of view, this material can be used for eco-friendly packaging, decorative coatings, handmade products, and design items.

CONCLUSION

The results of the study showed that it is possible to obtain a biocomposite material with bioleather properties from local fruit peel waste. Among the prepared samples, the composition containing 10% fruit peel powder gave the most optimal result, as the material was flexible, dense, smooth-surfaced, and had a bioleather-like appearance. Glycerin improved the flexibility of the material, while calcium chloride enhanced its density and water resistance. The practical significance of this work is explained by the possibility of obtaining an environmentally safe and useful material from food waste. In future studies, it is advisable to investigate the mechanical strength, water resistance, and biodegradation period of the material in more detail.

REFERENCES

1. Mohanty A.K., Misra M., Drzal L.T. Natural Fibers, Biopolymers, and Biocomposites. Boca Raton: CRC Press, 2005.
2. Robertson G.L. Food Packaging: Principles and Practice. 3rd edition. Boca Raton: CRC Press, 2012.
3. Han J.H. Innovations in Food Packaging. 2nd edition. London: Academic Press, 2014.

4. Siracusa V., Rocculi P., Romani S., Rosa M.D. Biodegradable polymers for food packaging: a review. Trends in Food Science & Technology, 2008, 19(12): 634–643.
5. Rhim J.W., Park H.M., Ha C.S. Bio-nanocomposites for food packaging applications. Progress in Polymer Science, 2013, 38(10–11): 1629–1652.
6. Azeredo H.M.C. Nanocomposites for food packaging applications. Food Research International, 2009, 42(9): 1240–1253.8.