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DEVELOPMENT OF TECHNOLOGY FOR PRODUCING LEATHER FROM AFRICAN CATFISH SKINS

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Abstract: The article develops and substantiates a technological system for processing African catfish skin and producing leather from it. It is emphasized that taking into account the individual characteristics of fish skin during processing creates the prerequisites for obtaining high-quality products. It is established that processing fish skin has socio-economic advantages: it is a renewable resource, facilitates waste utilization, and enables the production of a new range of leather materials. There are two most important new features in this article: one of this is a personalised degreasing protocol for the high lipid content ($22.8 \pm 2.1\%$) and second one is better chrome tanning settings that make collagen more stable. The key point of the process is to work at low temperatures and keep the pH level just right so that enzymes do not break down the skin. Although, the leather taken from this process has a grain pattern and mechanical properties that make it good for high-end uses.

Keywords: african catfish, skin structure, epidermis, dermis, hypodermis, goblet cells, fish skin, process flow chart.

Introduction. The development of technologies for producing leather from fish skins creates significant opportunities for the leather industry. This primarily serves to expand the raw material base and increase the range of manufactured products. Leather obtained from fish skin can be effectively used in various fields, including as a material for the upper part of footwear, as well as for producing haberdashery items—bags, belts, waistbands, and various decorative accessories. Another key advantage of such leather is that it possesses a unique aesthetic appearance, standing out among the range of various natural leathers [1-2].

In ancient times, the peoples of Southeast Asia, Southern Europe, North America, and Siberia were engaged in producing leather from the skins of large ocean fish, including shark, ray, tuna, wolffish, and moray eel. They mainly used vegetable-based tanning methods and also produced rawhide. The obtained leather [3] was primarily used for coarse clothing, footwear, decorating parts of dwellings, and some water transport vehicles.

Furthermore, in other works [4-6], Atlantic salmon skin was studied as a new type of raw material for leather production. The organoleptic indicators of the skin were analyzed, its histological structure (epidermis, dermis, subcutaneous fat layer) and its commercial-technological properties were examined. According to the research results, the fat content in Atlantic salmon skin ranged from 18.3% to 25.9%, which is close to the fat content in sheep and pig skin. The mineral substance content was determined to be around 1.3–2.5%. Based on the structure of collagen fibers and their interconnection

characteristics, the author concludes that it is possible to obtain elastic, durable, and high-quality leather from fish skins [7-9].

It should be emphasized that fish skin is considered a by-product obtained during the processing of fish industry waste [10]. The main goal of fish farming and processing is to obtain food, while the skin constitutes a very small part of the product's value. Thus, using fish skin in leather production contributes to the efficient use of a renewable resource and prevents its unnecessary loss.

In production practice, fish skin is viewed entirely as a by-product. For example, the fish leather produced by the Nordic Fish Leather tannery in Iceland is processed using the chrome tanning method and subsequently dyed with traditional Icelandic and Japanese natural dyes. Chrome tanning is currently considered the most widely used tanning method in the world. Its essence lies in tanning fish skin based on chromium sulfate [11]. Although the process takes one day, it allows for obtaining leather that is softer and more delicate compared to traditional methods.

The African sharptooth catfish (*Clarias gariepinus*) is considered a species obtained by crossing the female *C. fuscus*, native to Taiwan, with the male *C. mossambicus*, which is widespread in Africa and grows very quickly [12]. *C. gariepinus* possesses excellent characteristics; it grows faster than local catfish and can reach a large size in a short time. Therefore, *C. gariepinus* is now widely cultivated by the local population. Furthermore, the farming and consumption of catfish is increasing year by year.

By developing a comprehensive technological framework specifically for processing African catfish skin, this study addresses significant gaps in existing knowledge. The study considers the unique histological and chemical properties of *C. gariepinus* skins to determine the optimal parameters for every processing step, from initial operations to finalisation. The objectives of the research are to: (1) determine the nature of the raw materials; (2) develop processing technology that is suitable for each species; (3) assess the quality of the resulting leather; and (4) ensure that it is suitable for use in industry [13-15]. Beyond merely advancing technology, this work benefits the economy and the environment.

II. Assessing of African catfish structure.

African catfish skin mainly consists of three layers: the outer layer is the epidermis, the inner layer is the dermis, and the hypodermis. The epidermal layer always feels moist because it is covered with a slimy substance produced by goblet cells. The dermis contains blood vessels, nerve fibers, and connective tissue (see Figure 1).

Animal skin has a highly complex chemical composition, and its properties change significantly depending on the animal species, rearing and feeding conditions, climate, genetic factors, and age. The main mass of skin is constituted by water; the amount of water affects the speed of all physicochemical processes within the tissue, the growth of microorganisms, and the degradation of protein fibers. Among the organic components, proteins account for the largest share: among them, fibrillar proteins perform the primary function, determining the skin's elasticity, strength, and ability to retain shape. Simultaneously, fats and lipids affect the skin's softness, hydrophilicity, and gloss;

carbohydrates and glycosaminoglycans fill the inter-fiber spaces and help retain moisture. Although the amounts of enzymes, hormones, and vitamins are small, they determine the biological activity of the tissue, accelerating or decelerating certain reactions. The inorganic part consists mainly of water and various mineral substances; ions such as calcium, sodium, potassium, magnesium, phosphate, and others influence the balance between fibers, shaping the physicochemical stability of the skin.

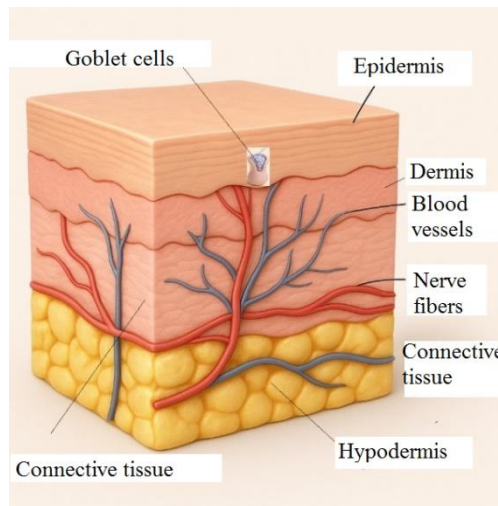


Figure 1. Structure of African Catfish Skin

Although fish skin has a composition similar to that of terrestrial mammals, some significant differences make it decompose more rapidly and be prone to biological degradation. Primarily, depending on the amount of albumins and globulins in fish, they are more sensitive to enzymes and external factors; as a result, the tissue can soften more quickly and its structure can deteriorate. Furthermore, fish tissues naturally contain active proteolytic enzymes (such as collagenase), which remain active even when freshly caught or under certain preservation conditions; therefore, enzymatic degradation is highly likely to occur within a short time. The high proportion of unsaturated fatty acids in fish oils accelerates oxidation processes, leading to intensified odor and color changes. The mucous layer on the surface and the microflora adhering to it create a favorable environment for bacterial proliferation; particularly, there are microorganisms capable of growing even at cold temperatures, which can lead to skin spoilage in a short time. Consequently, fish skin processing requires special attention, including careful removal of surface mucus, blood, and fat residues, and the necessity to correctly select production conditions to slow down enzymatic degradation.

III. Advanced technological system for African catfish skin and its discussion.

Given the development of fisheries in our country and the localization of the African catfish, a technology for producing leather from this fish's skin has been developed for productive utilization. The technological system for obtaining leather from the African catfish is presented in Figure 2 below.

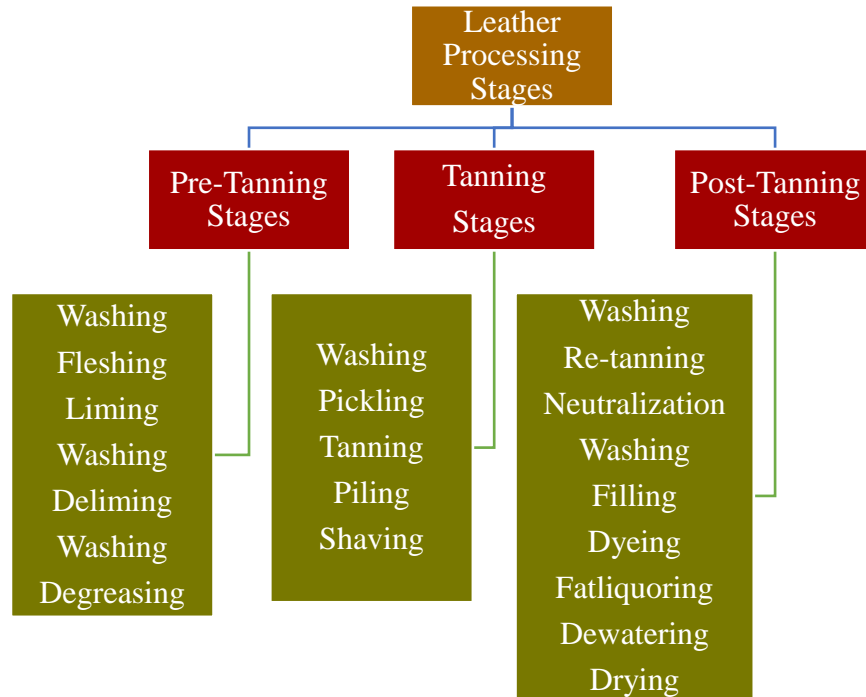


Figure 2. Technological System for Obtaining Leather from African Catfish Skin.

The system presented in Figure 2 illustrates the continuous production chain for converting African catfish skin into leather. The process begins with preparing the raw skin to adapt it to the technological environment: washing removes dirt, salt, and blood residues; during the fleshing process, the hypodermis is removed; then, liming and deliming processes are carried out to achieve fiber separation and softening, and to lower the pH. Due to the abundance of fats and lipids characteristic of fish skin, degreasing is performed to reduce the tendency for odor and oxidation. Afterwards, the skin is sent for pickling, where its porosity is increased, creating the necessary environment for chrome tanning. Tanning is typically carried out with chromium(III) salts, forming collagen-chromium complexes, which increases microbiological stability and heat resistance (see Figure 3).



After the washing process



Fleshing process



After the liming process



Figure 3. Photographs of the main technological processes for obtaining leather from African catfish skin

In the final stages, the semi-product is re-washed, and through processes of tanning replenishment and fatliquoring, the structure is strengthened, while dyeing and fatliquoring improve the aesthetic appearance and flexibility properties of the fish leather, while preserving its unique texture. Compared to the processing of mammalian animal skins, low temperature, a clean environment, control of time-reagent consumption, and pH control are considered crucial for all processes. As a result of processing within this system, raw fish skin can be transformed into leather with improved stability, elasticity, and aesthetic quality indicators (Figure 3).

IV. Conclusion.

In conclusion, the presented technological system offers a consistent and adaptable sequence of processes suitable for industrial application in processing African catfish skin. The development of fish skin processing technology allows for the expansion of the leather raw material base, the creation of waste-free technology, and the production of high value-added products for the haberdashery and footwear sectors.

The proposed technological chain for the processing of African catfish hides is a significant step forward in the development of this leather processing. This study also shows that this product can be converted into commercially viable leather with various modifications. The research conducted will effectively address the specific problems of the raw material, in particular its high fat content and tendency to rapid decomposition.

The proposed optimal process sequence (from preparation to finishing) ensures the preservation of the structural integrity of the hide and improves its functional properties. It is proven that tight control of chemical process parameters and processing conditions is essential for achieving quality results. The resulting hides not only meet technical standards for strength and durability, but also have unique aesthetic properties.

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