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A Comprehensive Review of Biochemical Analysis of Sheep By-Products

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Abstract

Sheep (*Ovis aries*) contribute significantly to global agriculture and industry through their primary products—meat, milk, and wool—and valuable by-products such as lanolin, bones, and bioactive compounds. This review provides a comprehensive analysis of the biochemical composition of sheep-derived by-products and highlights their industrial, nutritional, and environmental significance. Using advanced analytical techniques, significant progress has been made in characterizing proteins, lipids, carbohydrates, and minerals present in these materials. This paper also addresses challenges in utilizing sheep by-products and discusses future directions for research and sustainable practices.

Keywords: Sheep By-products, Lanolin, Oleic Acid, *Ovis aries*, Palmitic Acid, Sheep Wool

1. Introduction

Sheep have been domesticated for centuries, serving as a source of food, textiles, and industrial materials. While their meat and milk have been extensively studied, the biochemical potential of their by-products—including wool, bones, and lanolin—has only recently gained attention [1]. These by-products are rich in bioactive compounds and offer potential applications in nutraceuticals, cosmetics, biomedicine, and environmental sustainability.

Research and innovation have huge importance in sheep and goat meat production, processing as well as food safety. Special emphasis will be placed on the imaging and spectroscopic methods for predicting body composition, carcass and meat quality [2]. This paper delves into the biochemical composition of key sheep-derived materials, explores analytical methods used for characterization, and evaluates their applications across industries.

2. Biochemical Composition of Sheep By-Products

1. Wool

Wool, a primary by-product of sheep, is composed mainly of keratin, a fibrous structural protein [3]. There are currently no viable recycling options for the 10–15% of waste wool produced worldwide each year. In agriculture, leftover wool could be utilized as an organic amendment and source of nutrients. About 30% more organic carbon and nitrogen were added to the soil when waste wool was applied. Applying waste wool increased yield by 50% and water use efficiency by 30% compared to control. Higher biological fertility of the soil is indicated by higher soil enzymatic activity (11–27%) [4].

Composition:

- Proteins: Keratin (70-85%), which contains cysteine residues forming disulfide bonds responsible for wool's strength and elasticity [1].
- Lipids: Surface lipids include free fatty acids, wax esters, and cholesterol derivatives.
- Minerals: Sulfur, zinc, and calcium contribute to wool's unique properties.

Applications:

Keratin hydrolysates are used in regenerative medicine for tissue scaffolding.

Lanolin, derived from wool grease, is widely used in cosmetics and pharmaceuticals [5].

2. MILK:

- Sheep milk is known for its high nutritional content and biochemical richness:

Composition:

- Proteins (6-7%): Rich in caseins (α, β, κ) and whey proteins.
- Lipids (6-9%): High in medium-chain fatty acids like capric and caprylic acids.
- Carbohydrates (4.5-5.0%): Primarily lactose [6].

Micronutrients:

- Minerals: Calcium, phosphorus, potassium, and magnesium.
- Vitamins: A, D, E, and B-complex vitamins [7].

Applications:

- Used in the production of premium cheeses (e.g., Roquefort, Manchego).
- Bioactive peptides derived from milk proteins exhibit antihypertensive and antimicrobial properties.

3. BONES AND TISSUES

- Sheep bones and connective tissues are rich sources of minerals and bioactive compounds:

Bones:

- Major minerals: Calcium phosphate (hydroxyapatite) and magnesium.

Trace elements: Zinc and copper [8].

Tissues:

- Collagen: Found in connective tissue, used for gelatin and wound healing.
- Lipids: Rich in conjugated linoleic acid (CLA), a bioactive fatty acid with potential anti-cancer properties [9].

Applications:

- Collagen extracted from bones and tissues is used in biomedical applications.
- Bone meal is utilized as an organic fertilizer due to its high phosphorus content.

3. Analytical Techniques for Biochemical Analysis

1. Chromatography:

- Gas Chromatography (GC): Identifies and quantifies fatty acid profiles in wool lipids and lanolin.
- High-Performance Liquid Chromatography (HPLC): Separates and quantifies amino acids, peptides, and vitamins.

Spectroscopy:

- Fourier Transform Infrared (FTIR): Characterizes functional groups in keratin and lanolin.
- UV-Vis Spectroscopy: Measures protein and peptide concentrations in milk and tissue extracts.

Mass Spectrometry: Proteomics and Lipidomics are applied to identify and quantify complex molecules in milk and wool extracts.

Electrophoresis: SDS-PAGE: Used for protein profiling of milk proteins and wool keratin.

Table 1. Wool Composition

Component	**Percentage %**
Keratin	**75-85**
Lipids	**10-15**
Trace Elements	**2-5**
Others	**2-5**

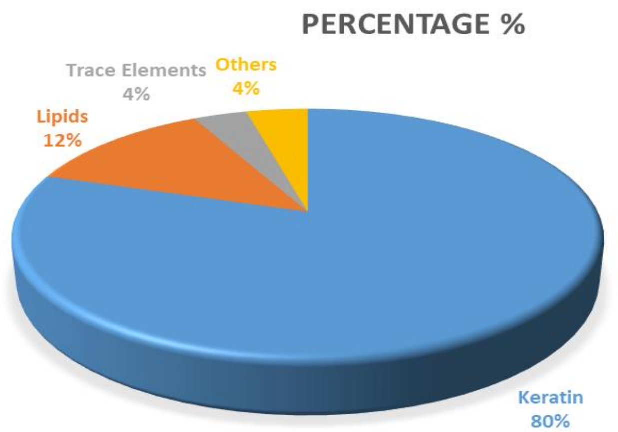

Fig. 1: Pie Chart Based om Table No. 1 Showing % Wise distribution of Wool Composition.

Table 2. Fatty Acid Composition of Lanolin [5]

Fatty Acid	Percentage %
Oleic Acid	40
Palmitic Acid	25
Linoleic Acid	15

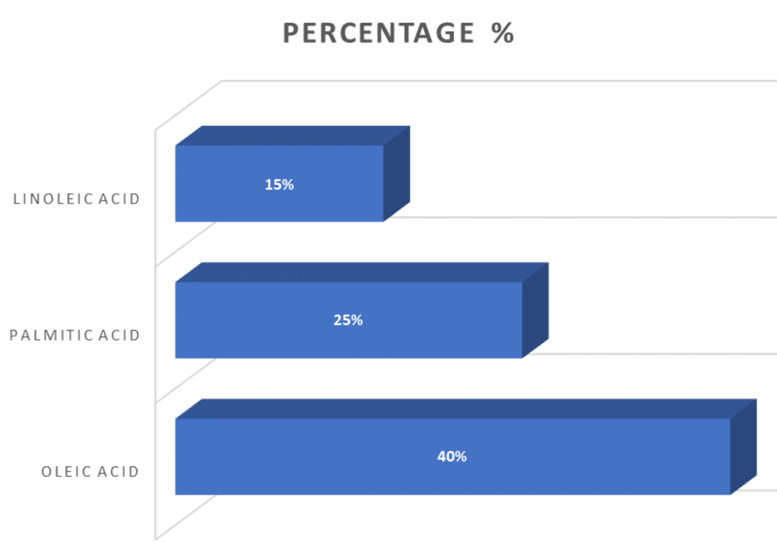

Fig. 2- Bar Graph Showing % wise Fatty Acid Composition of Lanolin developed from Table 2.

Table 3. Mineral Composition of Sheep Bones [8]

Mineral	Percentage (%)
Calcium	38-40%
Phosphorus	18-20%
Zinc	1-2%

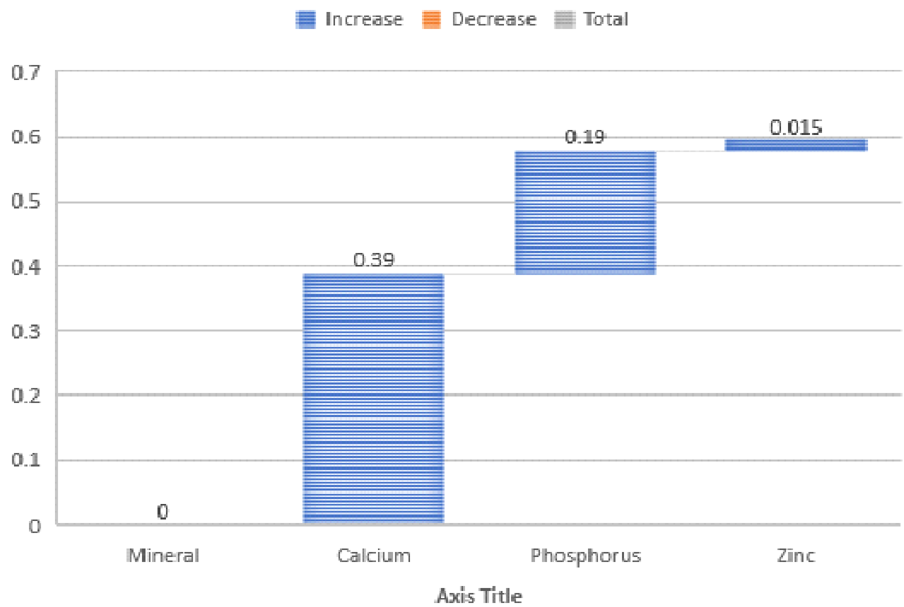

Fig. 3- Waterfall Graph Showing % Wise Distribution of Minerals in Composition of Sheep Bones

Table 4. Composition of Sheep Milk. [10]

Minerals	Percentage (% By Weight)
Protein	7
Fats	8
Lactose	5
Minerals	0.8

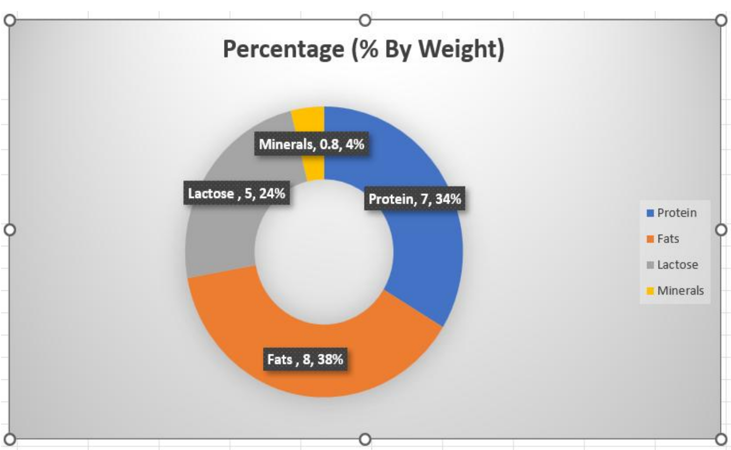

Fig. 4- Doughnut graph Showing % Wise Distribution of components in Sheep

4. Applications and Implications

A. Agricultural and Industrial Applications:

- Wool keratin is used in biodegradable plastics and textiles.
- Sheep milk-derived peptides have potential as dietary supplements.
- Bone meal serves as an organic fertilizer.

B. Biomedical Applications:

- Lanolin is used in pharmaceutical ointments for wound healing [5].
- Collagen and gelatine from tissues are used in regenerative medicine.

C. Environmental Sustainability:

- Sheep by-products like wool waste are being repurposed into eco-friendly composites.
- Utilizing bones as fertilizers reduces waste in sheep farming.

5. Challenges and Future Directions

Challenges:

- Breed-specific variability affects the composition of sheep by-products.
- Limited access to advanced biochemical analysis techniques in rural areas.

Future Directions:

- Genetic studies to enhance bioactive compound content in sheep products.
- Development of cost-effective methods for bioactive compound extraction.
- Large-scale studies on the environmental benefits of sheep by-product utilization.

6. Conclusion

Sheep by-products offer immense biochemical potential, with applications ranging from food and agriculture to medicine and industry. Advanced analytical methods have enabled the characterization of these materials, uncovering novel uses and promoting sustainable practices. Future research should focus on optimizing utilization and addressing region-specific challenges to enhance the value of these resources.

Conflicts of interest: The author stated that no conflicts of interest.

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