ENVIRONMENTAL ASPECTS OF THE LEATHER AND FUR INDUSTRY

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A REVIEW OF COLLAGEN EXTRACTION METHODS FROM THE LEATHER WASTES

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Leather industry plays a significant role in today's global economy. During the process of leather manufacturing, the hides and skins are trimmed. Thus the raw material are amenable for mechanical operations. This operation generates huge amounts of solid wastes. Globally, around 800 thousand tons of solid waste are processed per year. These wastes need to be utilized or submitted to appropriate treatment. In some countries, raw trimming wastes are used for the production of various products such as glue, collagen peptides, industrial gelatin, feed and fertilizers (Masilamani et al., 2016). Collagen is a product highly demanded in the market and used in making health care products, cosmetics, pharmaceutics, fodder and food (Martínez-Ortiz et al. 2014; Yang & Shu, 2014). This biopolymer can be found in animal's skin, bone, cartilage, tooth, tendon, ligament, and blood vessel (Yang & Shu, 2014). The aim of this work is to compare the commonly used methods of collagen extraction from mentioned sources.

Many reports have been described the extraction of the collagen (Martínez-Ortiz et al. 2014; Masilamani et al., 2016; Qiang et al. 2011; Yang & Shu, 2014). The most popular method for extraction is solubilisation using acetic acid (Martínez-Ortiz et al. 2014; Masilamani et al., 2016). The other commonly used methods, which can be found in literature, are: salting out method, alkaline method, and enzyme method (Yang & Shu, 2014). All these methods have been compared and described in Table 1. Solid leather waste contain a rich amount of collagen proteins which can be easily damaged while extracting and processing. This causes a not very high extraction rate of collagen protein. At the same time, there are a problem of pollution and high cost in the extraction of collagen protein. All mentioned methods have their own advantages and disadvantages. Therefore, scientists are exploring the possibility of a combination of two or more methods together in order to obtain a product of high purity at low cost. Liu et al. (2007) used acid-enzyme hybrid method to extract type-I collagen protein. They found that high collagen yield could be obtained following the extraction using acetic acid with pepsin. Also, Qiang et al. (2011) used a hybrid

method (alkali-enzyme) to extract collagen. The extraction rate of gelatin from chrome shavings was over 40%. What is interesting, Ran and Wang (2013) conducted the extraction of collagen from tendons of slaughtered cattle by use of ultrasonic and pepsin treatment in tandem. The results show that this method can effectively improve the efficiency of pepsin extraction of natural collagen without any compromise of the resultant collagen quality. Also, the extracted collagen possesses an intact molecular structure.

Table 1 – The extraction methods of collagen protein (Yang & Shu, 2014)

Methods	Mechanism	Chemicals	Advantages	Disadvantages
The salting out method	Collagen proteins have the properties of salt soluble and salting out.	Solution of NaCl, Tris-HCl, phosphate or citrate.	• It is good for the precipitate of type-I collagen.	• The salting out method is not stable. • Usage is limited.
The alkali method	Hydrolysis (large amounts of hydrolyzed collagen proteins are produced).	Lime, sodium hydroxide, sodium carbonate, magnesium oxide.	• Simple techniques. • Easy to control. • Involved reactions are mild. • The hydrolysis happens fast.	• Pollution for water, soil, air. • Consumes a huge amount of water. • Long cycle of extraction process. • Strongly corrosive to equipment.
The acid method	Acid of low concentration can destroy salt bonds between molecules and Schiff bases, and cause collagen fibers to expand and dissolve.	Acetic acid, citric acid or hydrochloric acid.	• The extraction fraction of collagen protein is high. • The hydrolysis happens fast. • Amino acids are easy to be destroyed and racemized.	• Strongly corrosive to equipment. • Pollution is serve.
The enzyme method	Enzymes act on non-helix peptide chains of collagen protein. Enzymes cut the collagen short at the position of N-terminal ¾.	Pepsin, papain, trypsase.	• Better reaction selectivity. • Less destructive to collagen protein. • High purity of products, stable physical and chemical properties. • Reaction conditions are mild. • No corrosion of equipment	• Hydrolysis is not complete. • Reaction time is long. • De-chroming is required. • There are too many steps. • The cost is high.

The collagen protein could be obtained from the leather wastes by the extraction using different methods. Thus, further research is still needed to study what methods are the most advantageous and effective.

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