

# Collagen analysis in mouse tissues using various assays

## Introduction

Collagens are the most abundant proteins in the vertebrate body. Accurate analysis of collagen is important both for research in diseases where collagen plays an important role and in the application of purified collagens in biomedical, cosmetic or nutraceutical industries.

Although in the human body collagen is a major component, it is a molecule that is difficult to purify and quantitate. This is partly due to the extensive network that is formed by collagen molecules via different types of crosslinking, which makes the collagen molecules insoluble and difficult to extract.

The number and type of commercially available collagen assays is limited. Some assays for soluble collagen exist, based on precipitation of collagen molecules with the dye Sirius Red. However, this assay seems less applicable for the analysis of collagen in tissues. The most widely used collagen assay is based on hydrolysis of collagen to free amino acids, followed by measuring collagen specific hydroxyproline, with either HPLC or a colorimetric method. However, these assays are laborious, time consuming and require special equipment. To overcome these disadvantages, we recently developed the QuickZyme Total Collagen assay, based on the same proven principles of acid hydrolysis and colorimetric detection, but much faster and without the requirement of special equipment.

*In this application note we have compared the different assays for their ability to measure collagen in a variety of mouse tissues. We used the QuickZyme Total Collagen Assay (acid hydrolysis, colorimetric detection of hydroxyproline), the HPLC 'golden standard' method (acid hydrolysis, HPLC detection of hydroxyproline) and the QuickZyme soluble collagen assay (extraction by acid/pepsin, Sirius red binding, colorimetric detection).*

## Methods

Healthy mice (C57Bl6, aged 8-10 weeks) were sacrificed and the following tissues were isolated: lung, liver, kidney, spleen, heart and dermis. In addition we used bovine tendon as a sample. The tissues / organs were divided in three parts, of which one part was used for wet weight determination, dry weight determination (after freeze drying the tissue), acid hydrolysis in 6 M HCl (10 mg wet tissue per 100  $\mu$ l 6M HCl, with a minimal volume of 200  $\mu$ l) and quantification of hydroxyproline either by HPLC, or using the colorimetric QuickZyme Total Collagen assay. Another part was used for wet weight determination followed by acid hydrolysis and hydroxyproline quantification using the QuickZyme Total Collagen assay. The third part was used for wet weight determination, collagen extraction by overnight incubation with 0.5 M acetic acid/pepsin followed by centrifugation and quantification using the Sirius Red based Soluble Collagen assay. See Fig.1 for assay principle of the various assays.

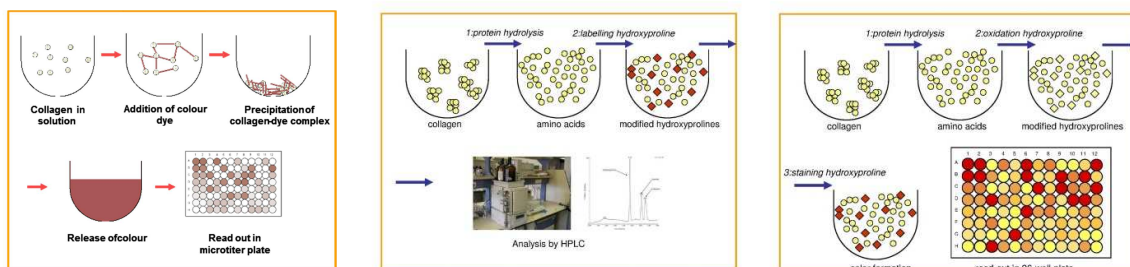


Fig 1. Assay principle of soluble collagen assay (left), total collagen assay by HPLC (middle) and colorimetric total collagen assay (right)

## Results

- The quantification of collagen by acid hydrolysis, followed by either HPLC, or the QuickZyme colorimetric assay correlates very good and yields similar values.
- Hydrolysis can either be performed with wet tissue or dry tissue with similar results.
- The analysis of solubilized collagen in the various tissues with the Sirius Red based Soluble collagen assay, gave varying results, the values were much lower than for total collagen and for many tissues even near the limit of detection. Compared to the QuickZyme total collagen assay the following percentages were obtained by the soluble collagen analysis: lung 2.5%, kidney 10%, spleen 8%, heart 14%, dermis 9%, liver 250%, tendon 3%. The low values are probably due to poor extraction of mature collagen from most of the tissues. Furthermore the values differed very much depending on the dilution.
- The amounts of collagen in the various mouse and bovine tissues measured by the different methods are shown in Table 1. It is clearly shown that the levels of collagen vary per organ, with dermis having the highest collagen content followed by lung, heart, kidney and liver.

Organ	lung	kidney	spleen	heart	skin	liver	tendon
Collagen <small>µg/mg wet weight tissue</small>	10	5	5	50	150	1	300

Table 1. Approximate amounts of collagen in various tissues (µg collagen per mg wet weight tissue), analyzed by acid hydrolysis followed by either HPLC or QuickZyme colorimetric assay. Analysis in either wet or dried tissue gave similar results.

- Tissue was hydrolyzed at 100 mg/ml (wet weight, see Table 3 for ratio wet/dry weight) in 6 M HCl (minimum volume of HCl 200 µl), the hydrolysate was diluted with 4M HCl as indicated in Table 2 and 35 µl of the diluted hydrolysate was used in the total collagen assay (see assay manual). The optimal dilution factor for analysis using the QuickZyme total collagen assay differed per tissue is shown in Table 2.

Organ	lung	kidney	spleen	heart	skin	liver	tendon
Dilution factor	10-50	10-50	10-50	10-50	50-500	10	100-1000

Table 2. Dilution factor range for collagen analysis using the QuickZyme total collagen assay.

Organ	lung	kidney	spleen	heart	skin	liver	tendon
Ratio wet/dry weight	5	4-5	4-5	4-5	3.5	3.5	3.5

Table 3. Approximate ratio of wet versus dry weight of various tissues.

## Conclusions

- The amount of collagen varies per tissue: tendon > skin > heart > lung > kidney > spleen > liver
- Sirius Red based collagen assays are less suited for collagen analysis in tissues, probably due to limited extraction of collagen from the tissues
- The best method for quantification of collagen in tissues is full hydrolysis of the tissue followed by analysis of hydroxyproline either by HPLC or by a colorimetric assay
- The QuickZyme total collagen assay is well suited for collagen analysis in tissues, gives similar results to HPLC, but is fast, easy and does not require special equipment.

## **QuickZyme Biosciences has developed a set of assays for the analysis of collagen from any species, each with a different application area**

Collagen assays available at QuickZyme Biosciences

- *QuickZyme Soluble collagen assay*
- *QuickZyme Total collagen assay*
- *QuickZyme Hydroxyproline assay*

### **QuickZyme Soluble collagen assay**

This assay recognizes soluble or (acid/pepsin) solubilized collagen.

The assay is colorimetric, has a 96-well plate format and is based on precipitation of collagen with Sirius-Red, an anionic dye with sulphonic acid groups. This dye can bind the side-chain groups of basic amino acid residues. The dye is released from the precipitated complex at high pH followed by colorimetric detection. The assay is optimized such that other proteins (such as albumin) do not interfere. Gelatin (unfolded collagen) is not recognized by this assay.

*Application:* The assay is used for the measurement of (soluble) collagen in e.g. cell culture media, and (acid or acid/pepsin) solubilized collagens e.g. from cellular extracts. The assay has severe limitations for measuring collagen in tissue extracts.

### **QuickZyme Total collagen assay**

This assay recognizes all types of collagen irrespective of its form (mature, immature, procollagen, degraded collagen, crosslinked collagen, collagen from various sources).

The assay is colorimetric, has a 96-well plate format, and is based on the quantification of hydroxyproline, an amino acid exclusively occurring in collagen. Hydroxyproline is released from collagen upon acid hydrolysis of the collagen containing sample. Hydrolysis is carried out at 95 °C, and the product can directly be used for hydroxyproline analysis, without washing or drying steps. This analysis is based on established Chloramine T/DMBA methodology.

*Application:* The assay is used for the measurement of total collagen. This includes all collagen types and forms, such as: procollagen, unfolded collagen, mature collagen as well as collagen degradation products of all collagen types present in the sample. Since the first step is complete hydrolysis of the sample, difficulty in extraction of collagen plays no role. The assay is applicable for all types of samples, including tissue.

### **QuickZyme Hydroxyproline assay**

This assay is similar to the total collagen assay, with the difference that no protocols and materials are included for collagen hydrolysis and no collagen standard, but a hydroxyproline standard is provided.

*Application:* This assay has the same application area as the total collagen assay, but is intended for customers who have their own hydrolysis method, or have a collection of hydrolyzed samples to be analyzed.

For more detailed information (including assay manuals) on

QuickZyme Soluble collagen assay: [www.quickzyme.com/products/collagen-assay](http://www.quickzyme.com/products/collagen-assay)

QuickZyme Total collagen assay: [www.quickzyme.com/products/total-collagen-assay](http://www.quickzyme.com/products/total-collagen-assay)

QuickZyme Hydroxyproline assay: [www.quickzyme.com/products/hydroxyproline-assay](http://www.quickzyme.com/products/hydroxyproline-assay)

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## **QuickZyme BioSciences**

P.O.Box 2215

2301 CE Leiden

The Netherlands

T: +31-88-8666114 / 8666024 / 8666134

F: +31-88-8660609

[www.QuickZyme.com](http://www.QuickZyme.com)

E-mail: [info@QuickZyme.com](mailto:info@QuickZyme.com)

