Measurement of Fish Gelatin using Rotational Viscometer: An Alternative to Conventional Pipette Method

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Abstract. The pipette method is a conventional method commonly used for determining the viscosity of gelatin. The purpose of this research was to study the use of a rotational viscometer to measure the viscosity of fish gelatin. The rotational viscometer has a wide measuring range and a limitation on low viscosity liquid measurements such as fish gelatin, so it is necessary to verify the sensitivity of the rotational viscometer to measure the viscosity of fish gelatin. In this study, low range manual rotational viscometer (MLV), low range digital rotational viscometer (DLV), low range digital rotational viscometer with low viscosity adapter (DLV + UL) were tested for their sensitivity to read standard solutions of 4.8 cP and 48.8 cP. The results showed that DLV + UL generated a high accuracy in reading 4.8 cP and 48.8 cP standard solutions with the recovery value of 102.5% and 99.5%, respectively. Measurement of the viscosity of commercial fish gelatin seven times obtained a coefficient of variance of 2.98% indicating a high degree of precision, with a recovery value of 103.54% of the value of the secondary reference material analysis certificate. The number of samples required for DLV + UL is 16 mL, while the conventional method required a sample of 100 mL. We proposed using DLV + UL for testing the viscosity of fish gelatin.

1. Introduction

Gelatin is a protein polymer obtained from the hydrolysis of collagen [1]. Gelatin is widely used in the food industry, pharmaceutical industry, and cosmetics industry [2] due to its gelling forming properties [3], film-forming [4], and soft capsule [5]. Besides, viscosity is one of the parameters that is often measured and used as one of the quality standards for gelatin [6,7].

The Indonesian National Standard 01-3735-1995 on Quality and Method of Gelatin Test have been provided the standard testing method for gelatin including chemical testing methods, heavy metals, color, and drying loss, however, there is no procedure to physical properties of gelatin e.g. bloom value and viscosity. After gelatin gel strength, viscosity is the second most important commercial property [8]. The gelatin viscosity testing method has been described in the Gelatine Manufacture Institute of America (GMIA) [9] and Gelatine Manufacturers of Europe (GME) [10] using conventional pipettes.

Both rotary and oscillating rheometers have been recommended as an alternative to the conventional pipette method for testing gelatin viscosity because of their high accuracy, small sample size, and dynamic viscosity. [11,12], however, the rheometer is still rarely owned by laboratories in Indonesia.
The conventional pipette method has the advantage of being easy for routine applications and useful for knowing whether the process is still within the tolerance value limit, but this method is rarely used because of the length measurement process.

Rotary viscometers have been widely used in test laboratories in Indonesia for measuring the viscosity of food and non-food products. In general, the viscosity test requires a fairly large sample, which is 500 mL. Rotary viscometers can also be used with adapters, such as adapters for small volume samples[13] and adapters for low-viscosity solutions [14]. However, there is no specific study regarding the use of a rotary viscometer to measure the viscosity of gelatin.

Fish Gelatin is a source of halal gelatin which is usually processed from the by-products of the fish processing industry in the form of skin, bones, and scales [15,16]. Fish gelatin has a relatively low viscosity value, gelatin from rainbow trout skin has a viscosity value of 1.26-3.53 cP, from tilapia fish skin of 3.2-7.12 cP[17], and the form tuna skins 3.8-8.6 cP[18].

The purpose of this study was to demonstrate the accuracy and precision of using a rotary viscometer to measure the viscosity of fish gelatin. The performance of rotary viscometers of various types and adapters were measured using standard low viscosity solutions of 4.8 cP and 48.8 cP. Then commercial gelatin (6.65%) was used to determine the level of precision and accuracy of the use of a viscometer.

2. Methods

2.1. Material

The viscosity standard solutions were supplied by AMETEK-Brookfield with a certificate reference value of 4.8 cP and 48.8 cP at 25°C. The accepted error for viscosity standard solution is 1% of the true value.

The granule fish gelatin was supplied by Xian Sonwu Biological Technology Co.LTD (Xian, China), with a certificate of analysis 2.5-5.5 cP at 40°C, that granule fish gelatin was milling using a Retsch Ultra Centrifugal Mill ZM 200 (Haan, Germany) equipped with 100 um Sieve sizes. The powdered gelatin was stored in silica gel containing desiccators for 30 days before packed into a single used 20 g sealed aluminum-plastics.

2.2. Tool

The viscometers used in this study were a low range analog rotary viscometer (MLV) (LVT, AMETEK-Brookfield), a low range digital rotational viscometer (DLV) (DV2T, AMETEK-Brookfield), and a low range digital rotational viscometer with an ultra-low adapter (DLV) (DLV + UL) (DV2T + Ultra Low adapter, AMETEK-Brookfield).

2.3. Assessments of the accuracy and precision of viscosity measurements

The viscosity of the standard solution was measured seven times with the most suitable speed to obtain a torque value of more than 10% so that the most precise data would be obtained. Spindle No. 61 was used on the DLV and MLV viscometers which had a measuring range of 15 cP-20000 cP. Whereas for DLV + UL the type of spindle used was the ULA spindle with a measuring range of 1-2000 cP. The calculation of the accepted value for the standard solution followed the guidelines for calculating the acceptability value as stated in the Brookfield Book Manual. In brief, the standard solution acceptance range was the certificate value with a 1% standard solution value and 1% error reading from the full-scale range. (Brookfield Ltd, n.d.). The viscometer is considered to have good performance in measuring the viscosity of standard solutions of 4.8 and 48.8 cP if the readings are within the acceptable range of standard sequential values and the measured torque value was greater than 10%. So, it is thought to be
able to measure the viscosity of fish gelatin, because the viscosity of fish gelatin had a low viscosity range.

2.4 Measurement of viscosity of fish gelatin using DLV + UL
A 6.65% gelatin solution in water was prepared following the standard method of preparing gelatin for bloom and viscosity tests[9,20]. A total of 16 mL of gelatin solution was measured using a DLV + UL viscometer 7 times by two analysts at temperatures of 40 and 60°C. The accuracy and accuracy of the fish gelatin viscosity measurement using a DLV + UL viscometer were calculated.

3. Result and Discussion
3.1. Accuracy and precision of viscosity measurements using a rotational viscometer
Rotational viscometers are widely used in laboratories and industry because they are easy to use, however, their use to measure the low viscosity solution and a limited number of samples e.g fish gelatin requires verification to obtain accurate test results. The results showed that gelatin had a relatively low viscosity ranging from 1.26-10 cP depending on the type of fish and the preparation technique. [16–18].

Table 1. Accuracy and precision of viscosity measurements using viscometer rotary MLV

| CRM value (cP) | 1% of CRM value (cP) | RPM | Full Scale Range/FSR (cP) | 1% of FSR (cP) | % Torque (must be >10%) | Viscosity reading (cP) | Acceptable accuracy range (cP) | Recovery CRM (%) | Verification |
|---------------|----------------------|-----|---------------------------|---------------|------------------------|----------------------|-----------------------------|----------------|--------------|
| 4.8           | 0.048                | 100 | 59.99                     | 0.6           | 10.8                   | 6.5                  | 4.15-5.45                  | 135.41         | FALSE        |
| 4.8           | 0.048                | 100 | 59.99                     | 0.6           | 10.8                   | 6.5                  | 4.15-5.45                  | 135.41         | FALSE        |
| 4.8           | 0.048                | 100 | 59.99                     | 0.6           | 10.8                   | 6.5                  | 4.15-5.45                  | 135.41         | FALSE        |
| 4.8           | 0.048                | 100 | 59.99                     | 0.6           | 10.8                   | 6.5                  | 4.15-5.45                  | 135.41         | FALSE        |
| 4.8           | 0.048                | 100 | 59.99                     | 0.6           | 10.8                   | 6.5                  | 4.15-5.45                  | 135.41         | FALSE        |
| 4.8           | 0.048                | 100 | 59.99                     | 0.6           | 10.8                   | 6.5                  | 4.15-5.45                  | 135.41         | FALSE        |
| 48            | 0.48                 | 100 | 59.99                     | 0.6           | 79.2                   | 47.5                 | 46.92-49.08                | 98.96          | TRUE         |
| 48.8          | 0.48                 | 100 | 59.99                     | 0.6           | 79.2                   | 47.5                 | 46.92-49.08                | 98.96          | TRUE         |
| 48.8          | 0.48                 | 100 | 59.99                     | 0.6           | 79.2                   | 47.5                 | 46.92-49.08                | 98.96          | TRUE         |
| 48.8          | 0.48                 | 100 | 59.99                     | 0.6           | 79.2                   | 47.5                 | 46.92-49.08                | 98.96          | TRUE         |
| 48.8          | 0.48                 | 100 | 59.99                     | 0.6           | 79.2                   | 47.5                 | 46.92-49.08                | 98.96          | TRUE         |

Note: * CRM= certificate reference material, viscosity standard
  b Full-scale range is a full-scale capacity that can be read by the spindle at correspond rpm
  c Acceptable accuracy is the value of CRM ± total of 1% of FSR(cP) error and 1% of CRM value (cP)
  d Verification is TRUE if the viscosity reading is within the range of acceptable accuracy, and FALSE otherwise.
3.1.1. Accuracy and precision of viscometer rotary type LV

The verification result of the MLV viscometer using the standard solution is shown in Table 1. Measurement 500 mL of 4.8 cP viscosity standard solution obtained is a low accuracy with a recovery value of 135.41%, and then the average is 6.5 cP, which is higher than the acceptance range. This result is presumably because the LV viscometer has a minimum measurement range of 15 cP as reported in the manual, but this measurement has very good repeatability and a torque value above 10.8% as required in the verification.

Measurement of the 48.8 cP standard solution with the MLV viscometer shows accurate measurement results with a recovery value of 98.96% and an average reading of 47.5 cP which is in the acceptable standard range. A high torque value of 79.2% also generated a high repeatability value, which is the same value out of 7 measurements. The verification results using a standard solution of 4.8 and 48 cP showed that MLV viscometer was not able to read the low viscosity solution such as a gelatin solution.

3.1.2. Accuracy and precision of viscometer rotary type DLV

The results of measuring 500 mL of 4.8 cP and 48.8 cP standard solutions using a DLV viscometer are shown in Table 2. Measurement of the 4.8 cP standard solution is only able to obtain a very low torque value of 1.8-2.6%, with a recovery value that varies from 112.5% -163.75%, indicating very low repeatability. The measurement results of the standard solution fall within a too wide tolerance range, which is 3,048 cP (1% of CRM value + 1% of FSR). As with the manual type, the digital DLV type can read the 48.8 cP viscosity solution well, with a recovery value of 98.96% and a viscosity reading that falls into the standard solution acceptance value of 44.52-51.48 cP.

| CRM value (cP) | 1% of CRM value (cP) | RPM | Full Scale Range FSR (cP) | 1% of FSR (cP) | % Torque (must be >10%) | Viscosity reading (cP) | Acceptable accuracy range (cP) | Recovery CRM (%) | Verification |
|----------------|----------------------|-----|--------------------------|----------------|-------------------------|-----------------------|--------------------------|----------------|-------------|
| DLV            |                      |     |                          |                |                         |                       |                          |                |             |
| 4.8            | 0.048                | 100 | 299.94                   | 3              | 2.6                     | 7.86                  | 1.75-7.85               | 163.75         | FALSE       |
| 4.8            | 0.048                | 100 | 299.94                   | 3              | 2.1                     | 6.30                  | 1.75-7.85               | 131.25         | TRUE        |
| 4.8            | 0.048                | 100 | 299.94                   | 3              | 2.1                     | 6.20                  | 1.75-7.85               | 129.16         | TRUE        |
| 4.8            | 0.048                | 100 | 299.94                   | 3              | 1.8                     | 5.40                  | 1.75-7.85               | 112.50         | TRUE        |
| 4.8            | 0.048                | 100 | 299.94                   | 3              | 1.8                     | 5.40                  | 1.75-7.85               | 112.50         | TRUE        |
| 4.8            | 0.048                | 100 | 299.94                   | 3              | 1.8                     | 5.40                  | 1.75-7.85               | 112.50         | TRUE        |
| 4.8            | 0.048                | 100 | 299.94                   | 3              | 1.8                     | 5.40                  | 1.75-7.85               | 112.50         | TRUE        |
| 4.8            | 0.048                | 100 | 299.94                   | 3              | 1.8                     | 5.40                  | 1.75-7.85               | 112.50         | TRUE        |
| 4.8            | 0.048                | 100 | 299.94                   | 3              | 1.8                     | 5.40                  | 1.75-7.85               | 112.50         | TRUE        |
| 4.8            | 0.048                | 100 | 299.94                   | 3              | 1.8                     | 5.40                  | 1.75-7.85               | 112.50         | TRUE        |
| 4.8            | 0.048                | 100 | 299.94                   | 3              | 1.8                     | 5.40                  | 1.75-7.85               | 112.50         | TRUE        |
| 4.8            | 0.048                | 100 | 299.94                   | 3              | 1.8                     | 5.40                  | 1.75-7.85               | 112.50         | TRUE        |
| 4.8            | 0.048                | 100 | 299.94                   | 3              | 1.8                     | 5.40                  | 1.75-7.85               | 112.50         | TRUE        |
| 4.8            | 0.048                | 100 | 299.94                   | 3              | 1.8                     | 5.40                  | 1.75-7.85               | 112.50         | TRUE        |
| 4.8            | 0.048                | 100 | 299.94                   | 3              | 1.8                     | 5.40                  | 1.75-7.85               | 112.50         | TRUE        |
| 4.8            | 0.048                | 100 | 299.94                   | 3              | 1.8                     | 5.40                  | 1.75-7.85               | 112.50         | TRUE        |
| 4.8            | 0.048                | 100 | 299.94                   | 3              | 1.8                     | 5.40                  | 1.75-7.85               | 112.50         | TRUE        |
| 4.8            | 0.048                | 100 | 299.94                   | 3              | 1.8                     | 5.40                  | 1.75-7.85               | 112.50         | TRUE        |
| 4.8            | 0.048                | 100 | 299.94                   | 3              | 1.8                     | 5.40                  | 1.75-7.85               | 112.50         | TRUE        |
| 4.8            | 0.048                | 100 | 299.94                   | 3              | 1.8                     | 5.40                  | 1.75-7.85               | 112.50         | TRUE        |
| 4.8            | 0.048                | 100 | 299.94                   | 3              | 1.8                     | 5.40                  | 1.75-7.85               | 112.50         | TRUE        |

Note:  
* CRM= certificate reference material, viscosity standard  
* Full scale-range is a full-scale capacity that can read by that spindle at correspond rpm  
* Acceptable accuracy is the value of CRM ± total of 1% of FSR(cP) error and 1% of CRM value (cP)
3.1.3. Accuracy and precision of viscometer rotary type DLV+UL

The results of measuring 16 mL of 4.8 cP and 48.8 cP standard solutions using a DLV + UL viscometer is shown in Table 3. The reading of the standard solution 4.8 cP using DLV+UL solution obtains a torque value of 16.40%, with a precise recovery value of 102.5% of 7 times reading which indicates good repeatability. The average measurement value is 4.92 cP, which is still within the tolerance value range of 4.45-5.15 cP. DLV + UL is able to measure the viscosity of 48.8 cP with a recovery value of 99.95-102%, the reading results from seven replications show a small difference in the recovery value. The results of the viscosity measurement ranged from 47.62-48.08 cP with the amount of torque at the time of measurement of 95%.

Table 3. Accuracy and precision of viscosity measurements using viscometer rotary DLV+UL

| CRM value (cP) | CRM value (cP) | RPM | Full Scale Range/FSR (cP) | 1% of CRM value (cP) | Viscosity reading (cP) | Acceptable accuracy range (cP) | Recovery CRM (%) | Verification |
|----------------|----------------|-----|---------------------------|----------------------|-----------------------|-------------------------------|-----------------|-------------|
| DLV+UL         |                |     |                           |                       |                       |                               |                 |             |
| 4.8            | 0.048          | 100 | 29.99                     | 0.3                  | 16.40%                | 4.92                         | 4.45-5.15       | 102.5       | TRUE        |
| 4.8            | 0.048          | 100 | 29.99                     | 0.3                  | 16.40%                | 4.92                         | 4.45-5.15       | 102.5       | TRUE        |
| 4.8            | 0.048          | 100 | 29.99                     | 0.3                  | 16.40%                | 4.92                         | 4.45-5.15       | 102.5       | TRUE        |
| 4.8            | 0.048          | 100 | 29.99                     | 0.3                  | 16.40%                | 4.92                         | 4.45-5.15       | 102.5       | TRUE        |
| 4.8            | 0.048          | 100 | 29.99                     | 0.3                  | 16.40%                | 4.92                         | 4.45-5.15       | 102.5       | TRUE        |
| 4.8            | 0.048          | 100 | 29.99                     | 0.3                  | 16.40%                | 4.92                         | 4.45-5.15       | 102.5       | TRUE        |
| 4.8            | 0.048          | 100 | 29.99                     | 0.3                  | 16.40%                | 4.92                         | 4.45-5.15       | 102.5       | TRUE        |
| 4.8            | 0.048          | 100 | 29.99                     | 0.3                  | 16.40%                | 4.92                         | 4.45-5.15       | 102.5       | TRUE        |
| 4.8            | 0.048          | 100 | 29.99                     | 0.3                  | 16.40%                | 4.92                         | 4.45-5.15       | 102.5       | TRUE        |
| 4.8            | 0.048          | 100 | 29.99                     | 0.3                  | 16.40%                | 4.92                         | 4.45-5.15       | 102.5       | TRUE        |
| 4.8            | 0.048          | 100 | 29.99                     | 0.3                  | 16.40%                | 4.92                         | 4.45-5.15       | 102.5       | TRUE        |
| 4.8            | 0.048          | 100 | 29.99                     | 0.3                  | 16.40%                | 4.92                         | 4.45-5.15       | 102.5       | TRUE        |
| 4.8            | 0.048          | 100 | 29.99                     | 0.3                  | 16.40%                | 4.92                         | 4.45-5.15       | 102.5       | TRUE        |
| 4.8            | 0.048          | 100 | 29.99                     | 0.3                  | 16.40%                | 4.92                         | 4.45-5.15       | 102.5       | TRUE        |
| 4.8            | 0.048          | 100 | 29.99                     | 0.3                  | 16.40%                | 4.92                         | 4.45-5.15       | 102.5       | TRUE        |
| 4.8            | 0.048          | 100 | 29.99                     | 0.3                  | 16.40%                | 4.92                         | 4.45-5.15       | 102.5       | TRUE        |
| 4.8            | 0.048          | 100 | 29.99                     | 0.3                  | 16.40%                | 4.92                         | 4.45-5.15       | 102.5       | TRUE        |
| 4.8            | 0.048          | 100 | 29.99                     | 0.3                  | 16.40%                | 4.92                         | 4.45-5.15       | 102.5       | TRUE        |
| 4.8            | 0.048          | 100 | 29.99                     | 0.3                  | 16.40%                | 4.92                         | 4.45-5.15       | 102.5       | TRUE        |
| 4.8            | 0.048          | 100 | 29.99                     | 0.3                  | 16.40%                | 4.92                         | 4.45-5.15       | 102.5       | TRUE        |
| 4.8            | 0.048          | 100 | 29.99                     | 0.3                  | 16.40%                | 4.92                         | 4.45-5.15       | 102.5       | TRUE        |

Note: a CRM= certificate reference material, viscosity standard
b Full-scale range is a full-scale capacity that can read by that spindle at correspond rpm
c Acceptable accuracy is the value of CRM ± total of 1% of FSR(cP) error and 1% of CRM value (cP)
d Verification is TRUE if the viscosity reading is within the range of acceptable accuracy, and FALSE otherwise.

The results of the rotary verification of the MLV, DVL, and DLV + UL viscometers with 4.8 cP and 48.8 cP standard solutions can be concluded that the DVL + UL type rotary viscometer is able to read 4.8 cP and 48.8 cP standard solutions accurately and precisely. So it was recommended to continue to be verified using fish gelatin. This range of values was very important because gelatin had a relatively low viscosity that was between 2.0 to 7.0 mPas, or slightly higher with special specifications. [21].
3.2. Measurement viscosity of commercial gelatin using DLV+UL

Based on the product certificate, fish commercial gelatin was having a viscosity around 2.5-5.5 cP at 40°C. The 6.65% gelatin solution in water was measured seven times by two analysts at 40°C and 60°C to check the performance of DLV+UL to measure the fish gelatin solution. The viscosity reading of DLV+UL was analyzed to obtain the coefficient of variation (%), recovery, and Capability process (Cp), then the boxplots between analysts were displayed. The result of the analysis is shown in Table 4.

Table 4. Measurement viscosity of gelatin solution using DV2T+UL

| No. | Analyst/Calculation | Viscosity at a specific temperature (cP) | 40°C | 60°C |
|-----|---------------------|----------------------------------------|------|------|
| 1   | Analysis 1          |                                        | 5.09 | 3.22 |
| 2   |                     |                                        | 5.27 | 2.86 |
| 3   |                     |                                        | 4.93 | 2.90 |
| 4   |                     |                                        | 5.20 | 2.81 |
| 5   |                     |                                        | 5.03 | 2.83 |
| 6   |                     |                                        | 5.36 | 2.86 |
| 7   |                     |                                        | 5.36 | 2.93 |
|     | Average (cP)        |                                        | 5.18 | 2.92 |
|     | Standard deviation (cP) |                                  | 0.15 | 0.13 |
|     | CV (%)*             |                                        | 2.98 | 4.45 |
|     | Error (%)**         |                                        | 1.20 | 4.51 |
|     | Recovery (%)***     |                                        | 103.54 |     |
| 1   | Analyst 1           |                                        | 5.23 | 2.93 |
| 2   |                     |                                        | 5.27 | 2.58 |
| 3   |                     |                                        | 5.28 | 2.62 |
| 4   |                     |                                        | 5.29 | 2.81 |
| 5   |                     |                                        | 5.33 | 2.59 |
| 6   |                     |                                        | 5.36 | 2.58 |
| 7   |                     |                                        | 5.36 | 2.54 |
|     | Average (cP)        |                                        | 5.30 | 2.66 |
|     | Standard deviation (cP) |                                  | 0.05 | 0.14 |
|     | CV (%)*             |                                        | 0.85 | 5.09 |
|     | Error (%)**         |                                        | 1.20 | 4.51 |
|     | Recovery (%)***     |                                        | 106.06 |     |
|     | Combined Data       |                                        |      |      |
| X   | Average (cP)        |                                        | 5.24 | 2.79 |
|     | Standard deviation (cP) |                                  | 0.13 | 0.18 |
|     | CV (%)              |                                        | 2.48 | 6.55 |
| N   | Number of data      |                                        | 14   | 14   |
| R   | Range               |                                        | 0.43 | 0.68 |
| A2  | Constanta****       |                                        | 0.235 | 0.235|
| d2  | Constanta****       |                                        | 3.407 | 3.407|
| Spec| Uncertainty/specification***** |                        | 0.8 | 0.8 |
| CL  | X                   |                                        | 5.24 | 2.79 |
| UCL | X+A2R               |                                        | 5.34 | 2.95 |
| LCL | X-A2R               |                                        | 5.14 | 2.63 |
| USL | X+Spec              |                                        | 6.04 | 3.59 |
| LSL | X-Spec              |                                        | 4.44 | 1.99 |
| Cp  | USL-LSL/(6s)        |                                        | 2.11 | 1.34 |

* CV (coefficient of variant) is the standard deviation relative to the average
** The errors are the average of measurement of each analyst relative to the average of combined data
*** Recovery value is the average of measurement relative to the CoA value of commercial gelatin (5 cP).
**** A2 and d2 are the specific Constanta for X and R Chart
***** Spec is the combination of uncertainty of DV2T (0.3 cP) an acceptable error of gelatin solution (0.5 cP)
3.2.1. Coefficient of variation
The coefficient of variation (CV) is a measure of precision, the test results are good if the CV value is smaller than 10% [22]. The results showed that measurement viscosity of commercial fish gelatin at 60°C and 40°C with DLV + UL obtained CV value of 2.48% and 6.55% for measurement at 60°C and 40°C, respectively. This shows that the use of DLV + UL in measuring the viscosity of gelatin has good precision. The CV values of the two analysts at both temperature measurements were less than 10%.

3.2.2 Accuracy
Accuracy is the amount of recovery from the measurement of the viscosity of fish gelatin relative to the product certificate value at a temperature measurement of 40°C. The results show that the recovery value for each analyst was 103.54% and 106.06%, this value is still quite good with the recovery value still close to 100%.

3.2.3. Capability process index
The Process Capability Index (Cp) is an index that describes the ability of the process to produce products under expected requirements or specifications. The measurement system was capable if the measurement value had a capability index (Cp) > 1[23]. The results of the calculation of process capability (Cp) show that the viscosity test for fish gelatin had a Cp value of 2.11 and 1.34, indicating that DV2T + UL was capable of testing the viscosity of fish gelatin.

3.2.4. Boxplot analysis
The results of the box plot analysis show that there is no difference in the viscosity test results of fish gelatin between the two analysts at both 40°C and 60°C (Figure 1). The analysis showed that the viscosity of fish gelatin measured at 40°C was higher than that measured at 60°C, this was because at 40°C the gelatin matrix began to form so that the viscosity value was higher than 60°C. So that the test report needs to include the viscosity measurement temperature.

![Boxplot of gelatin viscosity between analysts at 40°C and 60°C](image)

**Figure 1.** Boxplot of gelatin viscosity between analysts at a) 40°C, b) 60°C measurement

4. Conclusion
The results of this study indicated that the use of the type LVD + UL viscometer could read the viscosity of the low solution which was the range of viscosity values for fish gelatin. The results of commercial...
fish gelatin measurement using this tool showed very good accuracy and precision so that it could be used as an alternative method for measuring the viscosity of fish gelatin.

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References
[1] Liu D, Nikoo M, Boran G, Zhou P and Regenstein J M 2015 Collagen and gelatin Annu. Rev. Food Sci. Technol. 6 527–57
[2] Mariod A A and Adam H F 2013 Review: Gelatin, source, extraction and industrial applications Acta Sci. Pol. Technol. Aliment. 12 135–47
[3] Djabourov, Madeleine, Leblond, Jacques and Papon, Pierre 1988 Gelation of aqueous gelatin solutions. II. Rheology of the sol-gel transition J. Phys. Fr. 49 333–43
[4] Sobral P J a, Menegalli F C, Hubinger M D and Roques M a 2001 Mechanical, water vapor barrier and thermal properties of gelatin based edible films Food Hydrocoll. 15 423–32
[5] Gullapalli R P 2010 Soft gelatin capsules J. Pharm. Sci. 99 P4107-4148
[6] Badan Standardisasi Nasional 2018 Gelatin ikan
[7] Suryanti S, Marseno D, Indrati R and Irianto H 2018 Pengaruh Jenis Asam dalam Isolasi Gelatin dari Kulit Ikan Nila (Oreochromis niloticus) terhadap Karakteristik Emulsi Agritech 37 410
[8] Koli J M, Basu S, Nayak B B, Patange S B, Pagarkar A U and Gudipati V 2012 Functional characteristics of gelatin extracted from skin and bone of Tiger-toothed croaker (Otolithes ruber) and Pink perch (Nemipterus japonicus) Food Bioprod. Process. 90 555–62
[9] Gelatin Manufacturers Institute of America 2013 Standard testing methods for edible gelatin (GMIA)
[10] Gelatine Manufacture of Europe 2017 Standardised methods for the testing of edible gelatine (Gelatine Manufacture of Erope)
[11] Yunoki S, Sugimoto K, Ohyabu Y, Ida H and Hiraoka Y 2019 Accurate and precise viscosity measurements of gelatin solutions using a rotational rheometer Food Sci. Technol. Res. 25 217–26
[12] Tomczynska-Mleko M, Brenner T, Nishinari K, Mleko S, Szwaigier D, Czernecki T and Wesolowska-Trojanowska M 2014 Rheological properties of mixed gels: Gelatin, konjac glucomannan and locust bean gum Food Sci. Technol. Res. 20 607–11
[13] Tabarestani H S, Maghsoudlou Y, Motamedzadegan A and Sadeghi Mahoonak A R 2010 Optimization of physico-chemical properties of gelatin extracted from fish skin of rainbow trout (Oncorhynchus mykiss) Bioresour. Technol. 101 6207–14
[14] Niu L, Zhou X, Yuan C, Bai Y, Lai K, Yang F and Huang Y 2013 Characterization of tilapia (Oreochromis niloticus) skin gelatin extracted with alkaline and different acid pretreatments Food Hydrocoll. 33 336–41
[15] Karayannakidis P D and Zotos A 2016 Fish Processing By-Products as a Potential Source of Gelatin: A Review J. Aquat. Food Prod. Technol. 25 65–92
[16] Suryanti, Indrati R, Irianto H E and Marseno D W 2016 Comparison study on the extraction of gelatin from nila fish (Oreochromis nilotichus) skin using acetic acid and citric acid Pakistan J. Nutr. 15 777–83
[17] Jamilah B and Harvinder K G 2002 Properties of gelatins from skins of fish - Black tilapia (Oreochromis mossambicus) and red tilapia (Oreochromis nilotica) Food Chem. 77 81–4
[18] Mafazah E M, Pranoto Y and Rohman A 2018 Extracting of yellowfin tuna (Thunnus albacares) fish skin gelatin as influenced by alkaline concentration and extraction times IOP Conf. Ser. Earth Environ. Sci. 139
[19] (Brookfield ltd) Brookfield DV2T Viscometer Operating Instructions vol 8139
[20] Badan Standardisasi Nasional 2019 Cara uji fisika gelatin ikan – Bagian 1 : Penentuan kekuatan gel ( nilai bloom )
[21] Johnston-Banks F 1990 Gelatin *Food gels* ed H P (London: Elsevier Applied Science Publishers)
[22] Firdaus H 2016 Metode Uji Tiupan Angin Kompor Gas Satu Tungku Berdasarkan SNi 7368:2011 *J. Standarisasi* 18 45–52
[23] Rabinovich S G 2010 *Evaluating Measurement Accuracy: A Practical Approach* (USA: Springer)