OIV-MA-AS313-25 Determination of L-lactic acid in wines by automated enzymatic method

Type III method

1. Scope of application

This method makes it possible to determine L-lactic acid in wine by specific enzyme analysis using an automatic sequential analyser.

In this document a collaborative study is reported which demonstrates application of the method for measurement of L-lactic acid in the range from 0.06 to 1.43 g/L.

Note: Where necessary each laboratory using this method may refine, and potentially widen, this range through a validation study.

2. Standard references

- OIV *Compendium of International Methods of Analysis*: Lactic acid – enzymatic method, OIV-MA-AS313-07,
- ISO 78-2: Chemistry – Layouts for standards.

3. Reaction principles

In the presence of nicotinamide adenine dinucleotide (NAD), L-lactic acid is oxidised to pyruvate in a reaction catalysed by L-lactate dehydrogenase (L-LDH). Since the equilibrium reaction is in favour of the lactate, it is necessary to remove the pyruvate formed which is converted into L-alanine in the presence of L-glutamate. This reaction is catalysed by glutamate pyruvate transaminase (GPT).

$$L-lactate + NAD^{+} \overset{L-LDH}{\longleftrightarrow} pyruvate + NADH + H^{+}$$

$$pyruvate + L-glutamate \overset{GPT}{\longleftrightarrow} pyruvate + NADH + H^{+}$$

The reduced nicotinamide adenine dinucleotide (NADH) produced is measured based on its absorption at 340 nm. It is proportional to the quantity of L-lactic acid.

4. Reagents and working solutions

During the analysis – unless stated otherwise – only use reagents of recognised analytical grade and water that is distilled, demineralised or of equivalent purity.

4.1. Reagents

4.1.1. Quality I or II water for analytical usage (ISO 3696 standard)
4.1.2. Glycylglycine (CAS no. 556-50-3)
4.1.3. Glutamic acid (CAS no. 56-86-0)
4.1.4. NAD (nicotinamide adenine dinucleotide) (CAS no. 53-84-9)
4.1.5. L-LDH (L-lactate dehydrogenase) (CAS no. 9001-60-9)
4.1.6. GPT (glutamate pyruvate transaminase) (CAS no. 9000-86-6)
4.1.7. L-lactic acid of purity ≥ 98% (CAS no. 79-33-4)
4.1.8. Polyvinylpyrrolidone (PVP) (CAS no. 9003-39-8)
4.1.9. Sodium hydroxide (CAS no. 1310-73-2)

Note 1: There are commercial kits for the determination of L-lactic acid. The user needs to check the composition to ensure it contains the above-indicated reagents.

Note 2: The use of PVP is recommended to eliminate any possible negative effect of tannins in wine on the enzyme's activitiy. Should the use of PVP not prove effective, the laboratory should ensure that the wine tannins do not interfere with the enzymes.

4.2. Working solutions

4.2.1. A pH 10 buffer (0.60 M glycylglycine, 0.1 M L-glutamic acid).

The preparation may be as follows:

- Glycylglycine (4.1.2): 4.75 g,
- glutamic acid (4.1.3): 0.88 g,
- PVP (4.1.8): 1 g,
- water for analytical usage (4.1.1): 50 mL.

The mixture is adjusted to pH 10 using a 10 M sodium hydroxide solution, then made up to 60 mL with water for analytical usage. This solution is stable for at least 4 weeks at 2-8 °C (approx.).

4.2.2. R1 working solution (example):

- water for analytical usage (4.1.1): 12 mL,
- NAD (4.1.4): 420 mg.

This solution is stable for at least 4 weeks at 2-8 °C (approx.).

4.2.3. R2 working solution (example):

- water for analytical usage (4.1.1): 1.2 mL,
- L-LDH (4.1.5): 7600 U,

- GPT(4.1.6): 2200 U.

This solution is stable for at least 4 weeks at 2-8 °C (approx.).

Calibration solutions

To ensure the closest possible connection to the International System of Units (SI), the calibration range should be created using pure solutions of L-lactic acid prepared by weighing and covering the measurement range.

5. Apparatus

5.1. Analyser

5.1.1. Equipment type

Automatic sequential analyser equipped with a spectrophotometer with a UV detector. The reaction temperature should be tightly controlled (generally 37 °C). The reaction cuvettes are glass, methacrylate or quartz. The equipment is controlled by software ensuring its operation, data acquisition and useful calculations.

5.1.2. Absorbance reading

The concentration of the analytes directly relates to the absorbance difference read by the spectrophotometer. The precision of the absorbance reading should be a minimum of 0.1 absorbance unit (AU). It is preferable not to use absorbance values higher than 2.0.

5.1.3. Precision of volumes collected

The precision of the volumes of reagents and samples collected by the pipettes of the analyser influences the measurement result. Quality control of the results using appropriate strategies (e.g. according to the guides published by the OIV) is recommended.

5.1.4. Reaction duration and temperature

In general, the reaction time is 10 minutes and the temperature is 37 °C. Certain pieces of apparatus may use slightly different values.

5.1.5. Wavelength

The wavelength of maximum absorption of the NADH formed by the reaction is 340 nm.

5.2. Balance

This should be calibrated to the International System of Units and have 1 mg precision.

pH meter

5.3. Measuring glassware

The measuring glassware for the preparation of reagents and calibration solutions is class A.

6. Sampling

6.1. Preparation of samples of musts and still wines

In most cases, wine and must samples may be analysed without preparation. In some cases, a preparation may be introduced:

- Filtration or centrifugation should be used for highly turbid samples.
- Sample dilution (manual or automatic) with water for analytical usage should be used for values exceeding the measurement range.

2. Preparation of samples of sparkling wine containing CO_2

Sparkling wine samples containing CO_2 may produce bubbling effects. They must be degassed beforehand by stirring under vacuum, ultrasonic processing or any method enabling the required degassing.

7. Procedure

Given that different analysers may be used, it is recommended that the conditions of use provided by the manufacturer be strictly observed. This also applies to the various enzymatic kits available on the market

The procedure takes place as follows:

- The sample (S) is placed in a reaction cuvette.
- Working solution R1 (4.2.2) is then added to the cuvette.
- The two are mixed together. Time is then allowed for a lag period, in order to guarantee absorbance stability. This lag period may last from 1-5 min, and is defined by the laboratory, according to the characteristics of the equipment used.
- Working solution R2 (4.2.3) is added and the reaction takes place.

By way of example, the quantities of different elements may be as follows:

- sample: 2.5 µL,
- buffer (80%) and R1 (20%): 120 µL,
- R2: 15 µL.

The equipment takes regular measurements that make it possible to obtain a reaction curve, an example of which is given in Figure 1.

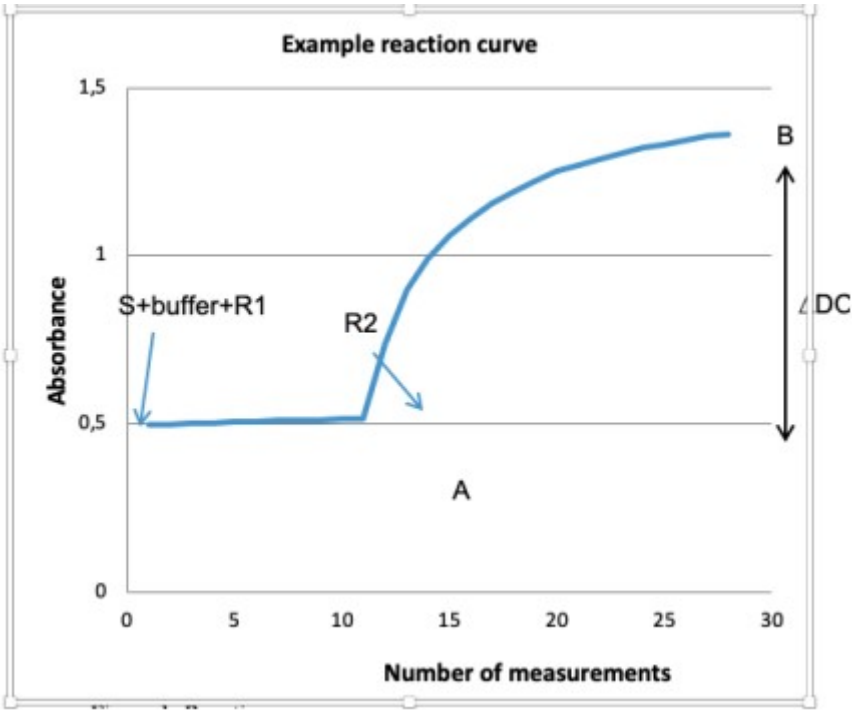

Figure 1: Reaction curve

The equipment makes it possible to choose the reading points for the difference in absorbance sought, for example A and B in Figure 1.

8. Calculation of results

The measurement used for the determination of the result is as follows:

$$\Delta DO = (Absorbance\ B - Absorbance\ A)$$

In order to correlate this ΔDO value with the desired concentration of L-lactic acid, regular calibration of the apparatus is carried out using the calibration solutions at a minimum of 3 points covering the measurement range used. In the example given in Figure 2, the calibration curve is a straight line for values between 0 to 1.22 g/L L-lactic acid. In this case, for higher values, it is preferably to carry out a dilution. Inaddition, a reagent blank is used comprising all of the reagents but no sample (point 0 of the calibration).

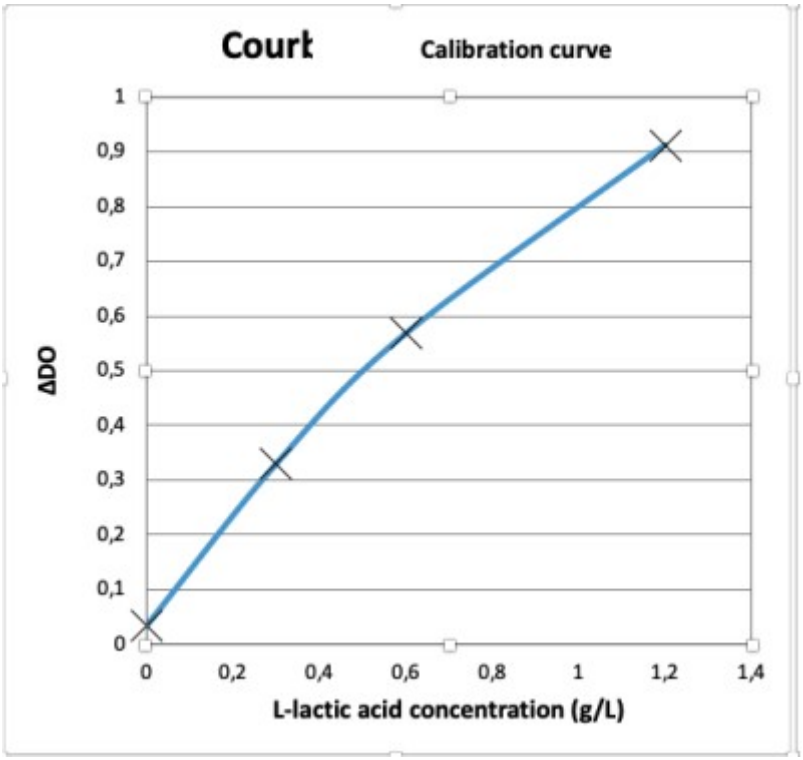

Figure 2: Calibration curve

The calibration curve can be order 1 (*Concentration* $= a\Delta DO + b$), yet in this method it is more generally order 2 (*Concentration* $= a\Delta DO^2 + b.\Delta DO + c$). If using a calibration curve of order 2, the laboratory should take care to limit the calibration domain in order to maintain sufficient sensitivity of the method (risk of crushing the curve with high concentrations).

The final value obtained should be multiplied by any coefficient of dilution used

9. Expression of results

The results are expressed in g/L of L-lactic acid to 2 d.p.

10. Precision

Interlaboratory reproducibility

- RSD_R = 7% (from 0.5 g/L)
- CV_R% (k=2) = 2·RSD_R = 14%, (from 0.5 g/L)

Repeatability

- RSD_r = 2% (from 0.5 g/L)
- CV_r% (k=2) = 2·RSD_r = 4% (from 0.5 g/L)

Limit of quantification

Validated LOQ = 0.06 g/L

(Concentration where CV_R% (k=2) = 60%)

Annex: Results of the interlaboratory tests

Collaborative study

A total of 16 laboratories from different countries participated in the collaborative study organised in 2016.

Labo	Country
Miguel Torres S.A.- Finca Mas La Plana	SPAIN
Estación Enológica de Castilla y León	SPAIN
INGACAL -Consellería do Medio Rural Estación de Viticultura e Enoloxía de Galicia	SPAIN
Estación Enológica de Haro	SPAIN
Comissão de Viticultura da Região dos Vinhos Verdes	PORTUGAL
Laboratoires Dubernet	FRANCE
Laboratoire Diœnos Rhône	FRANCE
Laboratoire Natoli	FRANCE
SCL Montpellier	FRANCE
Agricultural institute of Slovenia	SLOVENIA
Fachbereich: Wein, Weinüberwachung - Chemisches und Veterinärunterchungsamt Karlsruhe	GERMANY

HBLAuBA Wein - und Obstbau	AUSTRIA
Landesuntersuchungsamt Mainz	GERMANY
Hochschule GEISENHEIM University Institut Weinanalytik und Getränkeforschung	GERMANY
Unità Chimica Vitienologica e Agroalimentare - Centro Trasferimento Tecnologico - Fondazione Edmund Mach	ITALY
Unione Italiana Vini soc. Coop.	ITALY

For analysis, 2 x 10 blind duplicate samples were used, with 1 repetition. The wines analysed are wines originating from France and Portugal, dry wines and liqueur wine

Sample		A (liqueur wine)		B (dry wine)		C (dry wine)		D (dry wine)		E (dry wine)		F (dry wine)		G (dry wine)		H (sweetened wine)		I (sweetened wine)		J (sweetened wine)	
Position		1	9	2	13	3	4	5	15	6	10	16	20	7	11	12	17	8	19	14	18
Labo3	rep#1	0.17	0.14	0.04	0.04	**0.49**	**0.49**	0.68	0.73	**1.03**	**1.06**	*1.03*	*1.09*	1.34	1.31			**0.12**	**0.12**	1.36	1.34
	rep#2	0.18	0.17	0.01	0.02	**0.43**	**0.50**	0.68	0.68	**1.01**	**1.04**	*1.05*	*1.07*	1.28	1.26			**0.12**	**0.11**	1.24	1.32
Labo6	rep#1	0.19	0.19			**0.55**	**0.55**	0.77	0.73	**1.15**	**1.11**	*1.09*	*1.09*	1.42	1.39	0.04	0.03	0.14	0.13	**1.47**	**1.43**
	rep#2	0.14	0.14			**0.52**	**0.52**	0.75	0.71	**1.16**	**1.11**	*1.09*	*1.10*	1.44	1.41	0.03	0.03	0.08	0.07	**1.50**	**1.45**
Labo7	rep#1	0.16	0.17	0.04	0.04	0.51	0.52	0.72	0.73	1.09	1.05	*1.01*	*1.07*	1.33	1.36	0.03	0.03	0.12	0.13	1.42	1.42
	rep#2	0.17	0.17	0.03	0.04	0.50	0.50	0.72	0.72	1.05	1.09	*1.04*	*1.08*	1.34	1.32	0.02	0.03	0.12	0.12	1.44	1.43
Labo9	rep#1	0.15	0.14			0.50	0.54	0.70	0.70	1.09	1.10	*1.06*	*1.06*	1.31	1.27			0.11	0.07	1.41	1.43
	rep#2	0.14	0.15			0.50	0.52	0.69	0.74	1.10	1.08	*1.01*	*1.01*	1.29	1.27		0.01	0.10	0.12	1.37	1.33
Labo12	rep#1	0.17	0.18	0.08	0.08	**0.51**	**0.51**	0.74	0.75	1.06	1.04	*1.04*	*1.02*	1.34	1.34			0.16	0.16	1.40	1.40
	rep#2	0.17	0.18	0.08	0.08	**0.51**	**0.51**	0.74	0.76	1.04	1.00	*1.03*	*1.00*	1.34	1.36			0.17	0.18	1.40	1.42
Labo13	rep#1	0.16	0.16	0.05	0.05	0.49	0.48	0.71	0.72	**1.00**	**1.08**	*1.01*	*1.01*	1.30	1.42	0.03	0.03	0.12	0.12	1.39	1.41
	rep#2	0.16	0.17	0.05	0.05	0.49	0.50	0.71	0.73	**1.03**	**1.05**	*1.01*	*1.05*	1.29	1.33	0.02	0.02	0.13	0.12	1.37	1.37
Labo14	rep#1	0.15	0.14	0.02	0.02	0.61	0.61	0.79	0.79	1.20	1.21	*1.23*	*1.24*	1.53	1.49	0.01	0.01	0.10	0.10	1.59	1.58
	rep#2	0.14	0.14	0.02	0.02	0.60	0.61	0.79	0.79	1.22	1.21	*1.24*	*1.24*	1.53	1.52	0.01	0.01	0.10	0.10	1.59	1.59
Labo15	rep#1	**0.40**	**0.43**	0.09	0.08	1.00	0.98	1.03	1.07	1.69	1.68	*1.60*	*1.60*	2.04	2.10	0.06	0.07	0.24	0.19	2.07	2.06
	rep#2	**0.43**	**0.36**	0.03	0.03	0.95	0.99	1.05	1.09	1.64	1.68	*1.62*	*1.63*	2.04	2.03	0.04	0.01	0.16	0.19	2.17	2.01
Labo16	rep#1	**0.17**	**0.17**	0.03	0.03	0.53	0.53	0.73	0.75	1.14	1.12	*1.08*	*1.09*	1.37	1.38	**0.03**	**0.02**	0.12	0.13	**1.50**	**1.44**

	rep#2	**0.17**	**0.17**	0.03	0.05	0.55	0.53	0.74	0.74	1.15	1.13	*1.06*	*1.08*	1.40	1.37	**0.04**	**0.02**	0.12	0.12	**1.46**	**1.45**
Labo17	rep#1	0.12	0.13	0.02	0.02	0.46	0.45	0.65	0.71	1.01	1.01	*1.03*	*1.07*	1.20	1.18	0.01	0.01	0.10	0.09	1.36	1.36
	rep#2	0.12	0.13	0.03	0.03	0.46	0.48	0.69	0.70	1.05	1.07	*1.04*	*1.03*	1.29	1.32	0.01	0.01	0.08	0.10	1.37	1.37
Labo18	rep#1	0.16	0.15	0.04	0.04	0.44	0.43	0.64	0.63	0.95	0.95	***0.92***	***0.92***	1.19	1.17	0.03	0.03	0.11	0.11	1.23	1.25
	rep#2	0.14	0.15	0.04	0.04	0.44	0.45	0.63	0.63	0.94	0.95	***0.92***	***0.91***	1.18	1.17	0.03	0.03	0.11	0.11	1.26	1.26
Labo19	rep#1	0.16	0.16	0.04	0.04	0.55	0.58	0.79	0.80	1.18	1.21	***1.12***	***1.14***	1.42	1.45	0.02	0.02	0.13	0.13	1.49	1.50
	rep#2	0.16	0.16	0.04	0.04	0.56	0.56	0.78	0.74	1.13	1.15	***1.13***	***1.14***	1.43	1.46	0.03	0.02	0.13	0.13	1.51	1.51
Labo20	rep#1	0.17	0.18	0.04	0.04	0.53	0.53	0.74	0.75	1.11	1.09	*1.06*	*1.07*	1.30	1.32	0.03	0.03	0.13	0.13	1.39	1.42
	rep#2	0.17	0.18	0.04	0.04	0.53	0.53	0.74	0.75	1.11	1.09	*1.06*	*1.07*	1.30	1.32	0.03	0.03	0.13	0.13	1.39	1.42
Labo21	rep#1	0.18	0.18	0.05	0.05	0.56	0.56	0.79	0.80	1.17	1.22	*1.19*	*1.20*	1.46	1.50	0.05	0.05	0.13	0.13	1.54	1.58
	rep#2	0.17	0.18	0.05	0.05	0.56	0.56	0.79	0.81	1.19	1.21	*1.20*	*1.23*	1.47	1.48	0.05	0.05	0.13	0.13	1.55	1.57
Labo22	rep#1	0.24	0.23	0.05	0.06	0.53	0.51	0.70	0.72	1.04	1.10	*1.01*	*1.00*	1.29	1.28	0.05	0.04	**0.13**	**0.16**	**1.38**	**1.40**
	rep#2	0.24	0.22	0.05	0.05	0.52	0.52	0.70	0.74	1.04	1.06	*1.06*	*1.03*	1.29	1.29	0.05	0.04	**0.15**	**0.14**	**1.43**	**1.41**

Table of the data obtained. The values in bold correspond with the values rejected in accordance with the Cochran (variance outliers) test with a 2.5% significance level (one-tailed test), and the Grubbs (outliers from the mean) test with significance levels of 2.5% (two-tailed test).

Note: The absent values have not beeh provided by the laboratory in question.

Sample	A	B	C	D	E	F	G	H	I	J
No. of laboratories selected	12	12	13	14	14	14	12	12	12	12
No. of repetitions	4	4	4	4	4	4	4	4	4	4
Min.	0.13	0.02	0.44	0.63	0.95	0.92	1.18	0.01	0.09	1.25
Max.	0.18	0.08	0.61	0.80	1.21	1.24	1.52	0.05	0.17	1.59
Overall average	0.16	0.04	0.52	0.73	1.09	1.07	1.36	0.03	0.12	1.43
Repeatability variance	0.00005	0.00003	0.00011	0.00028	0.00053	0.00035	0.00032	0.00002	0.00004	0.00028
Inter-labo stand. dev.	0.02	0.02	0.04	0.04	0.07	0.08	0.10	0.01	0.02	0.09
Reproducibility variance	0.0003	0.0003	0.0020	0.0021	0.0057	0.0067	0.0093	0.0002	0.0004	0.0083
Repeatability standard dev.	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.00	0.01	0.02
r limit	0.02	0.02	0.03	0.05	0.06	0.05	0.05	0.01	0.02	0.05
Repeatability RSD_r	4.3%	14.1%	2.0%	2.3%	2.1%	1.8%	1.3%	16.9%	5.0%	1.2%
Reproducibility stand. dev.	0.02	0.02	0.04	0.05	0.08	0.08	0.10	0.01	0.02	0.09
R limit	0.05	0.05	0.13	0.13	0.21	0.23	0.27	0.04	0.06	0.26

Reproducibility RSD_R	10.5%	40.0%	8.5%	6.4%	7.0%	7.6%	7.1%	50.8%	16.5%	6.4%
Horwitz RSD_r	4.92	6.03	4.12	3.92	3.69	3.70	3.57	6.46	5.11	3.54
$Horrat_r$	0.87	2.33	0.49	0.59	0.57	0.48	0.37	2.62	0.98	0.33
Horwitz RSD_R	7.46	9.13	6.24	5.93	5.58	5.60	5.40	9.79	7.74	5.36
$Horrat_R$	1.41	4.38	1.36	1.07	1.25	1.36	1.32	5.19	2.13	1.19

Table of the results obtained

Note: The results from samples B and H should be taken with caution due to the very low concentration levels, which are below the laboratories' limit of quantification

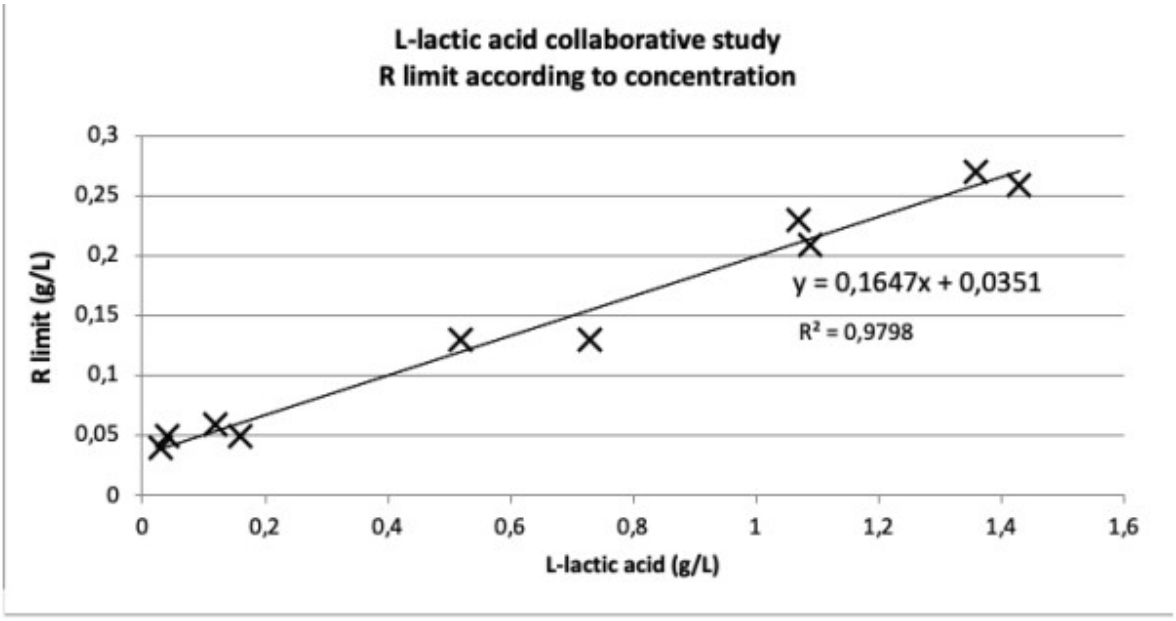

Figure 3: R limit according to concentration

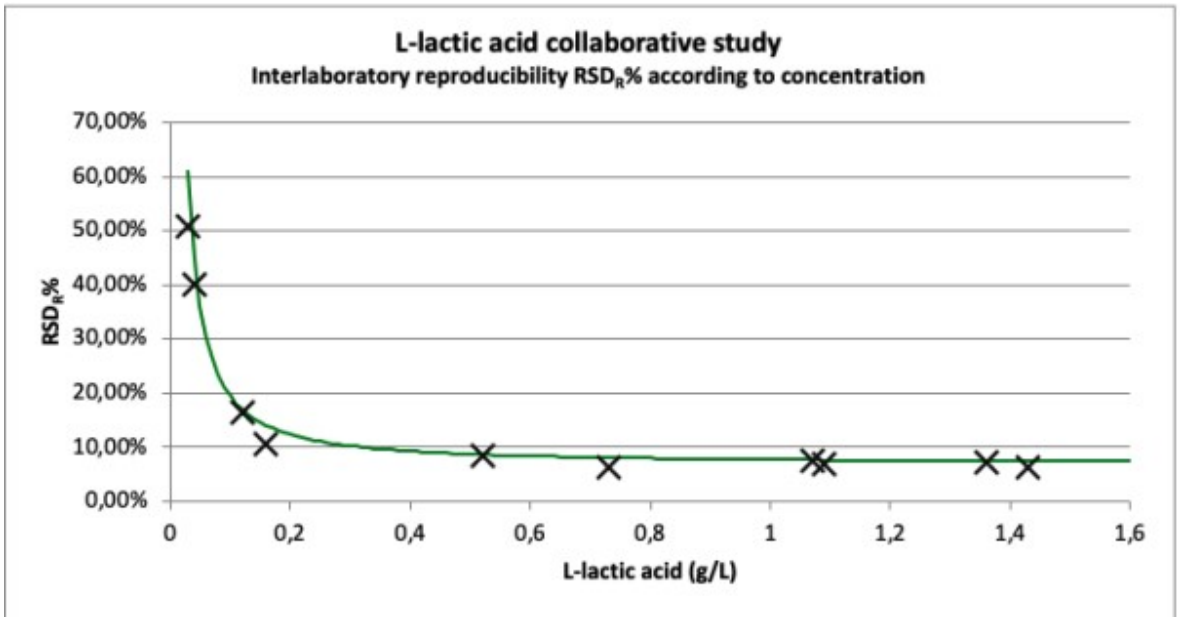

Figure 4: Interlaboratory RSDR% according to concentration.
Modelling: $RSD_R\% = 0.758 \cdot C^{(-1.216)} + 7$