# Restitution of trawl-caught fish and its effect on blood concentration in fillets

**THORSHAVN, WEFTA 2019**

Stein-Kato Lindberg
Scientist

Nofima





Nofima


Brinkhof J, Olsen SH, Ingólfsson ÓA, Herrmann B, Larsen RB (2018). *Sequential codend improves quality of trawl-caught cod*. https://doi.org/10.1371/journal.pone.0204328



Nofima

# Live storage

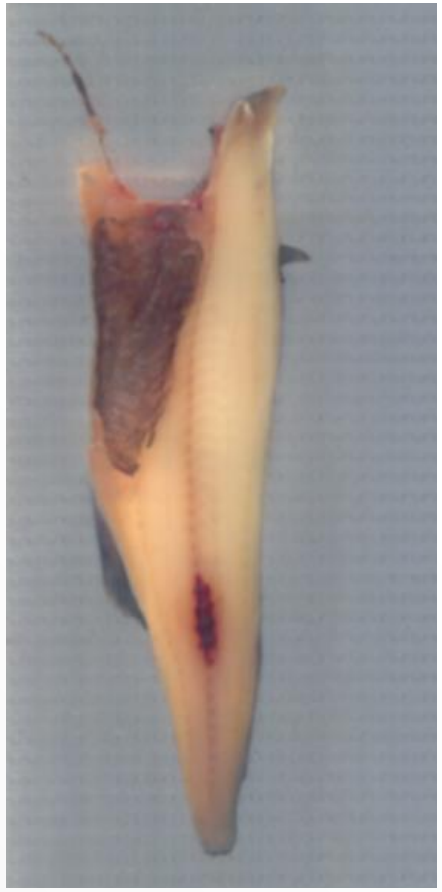
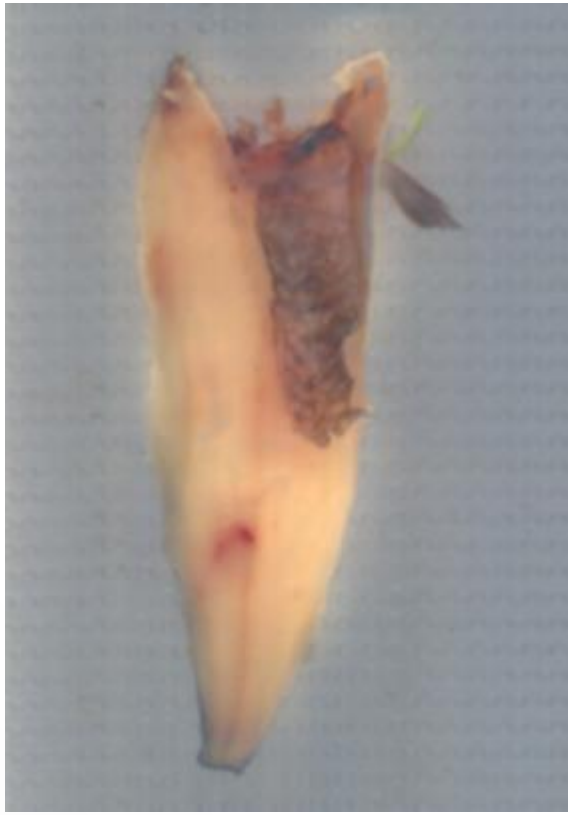
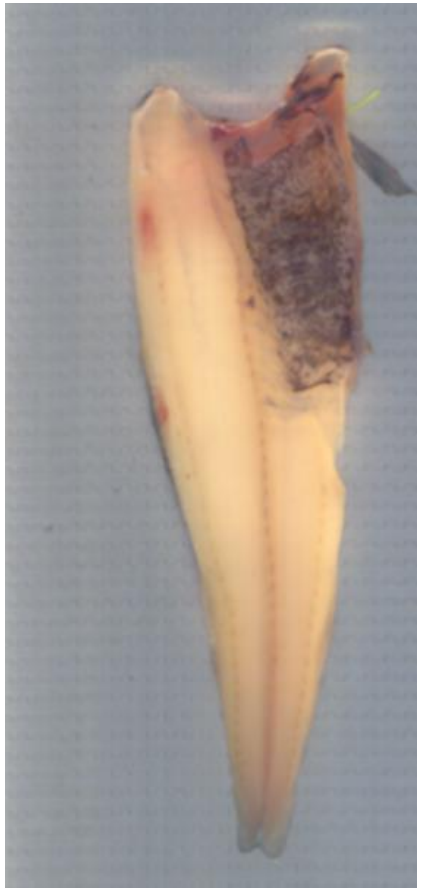
# Live storage

Immediate processing vs. 6 hours restitution

Olsen, S. H., Tobiassen, T., Akse, L., Evensen, T. H. and Midling, K. Ø. (2013). *Capture induced stress and live storage of Atlantic cod* (Gadus morhua) *caught by trawl: Consequences for the flesh quality.* http://dx.doi.org/10.1016/j.fishres.2013.03.009.

# Injuries during capture

Barotrauma, bruising and broken spine



Nofima

# Experimental design

Trawl-caught cod

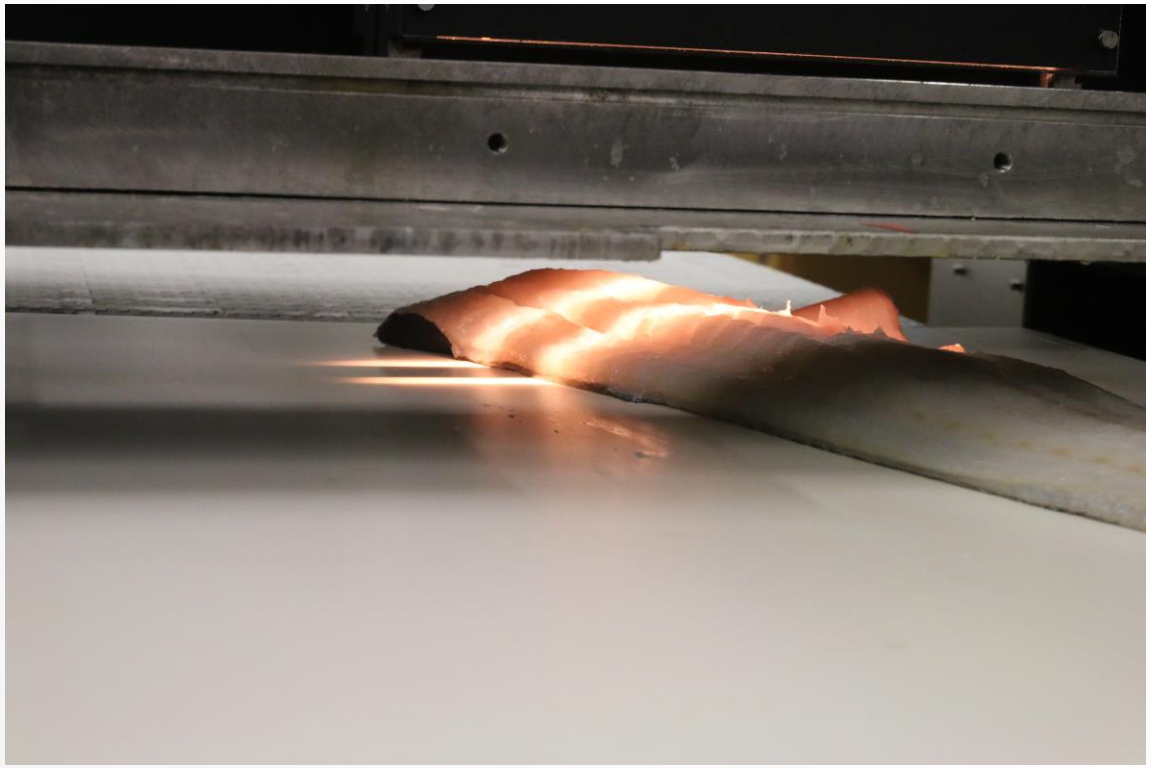
| Rest. time | 0 hrs | 0 hrs | 4 hrs | 72 hrs | 96 hrs | 168 hrs | 674 hrs |
|---|---|---|---|---|---|---|---|
| Haul number | 11 | 16 | 4 | 4 | 4 | 18 | 18 |
| Sample size | 14 | 12 | 11 | 12 | 14 | 12 | 12 |
| Missing samples | 1 | 1 | 11 | 1 | 0 | 1 | 1 |
| Available number of samples | 13 | 11 | 0 | 11 | 14 | 11 | 11 |

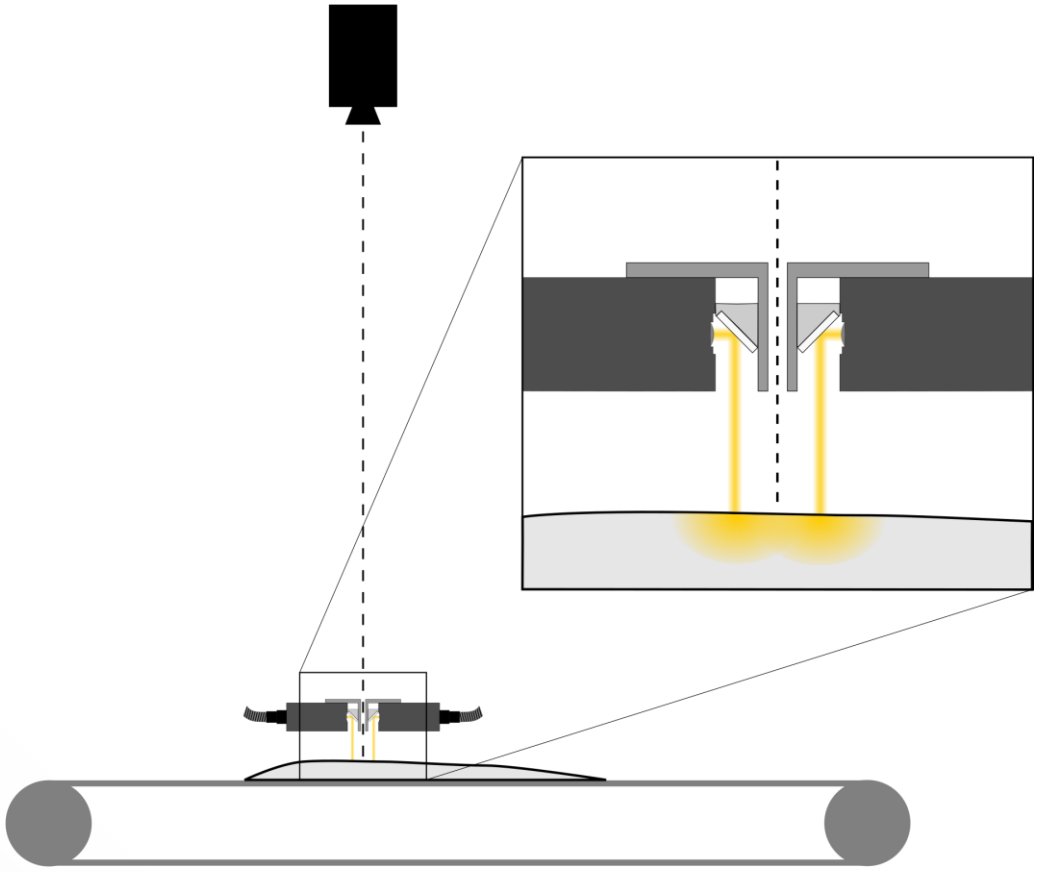


Nofima

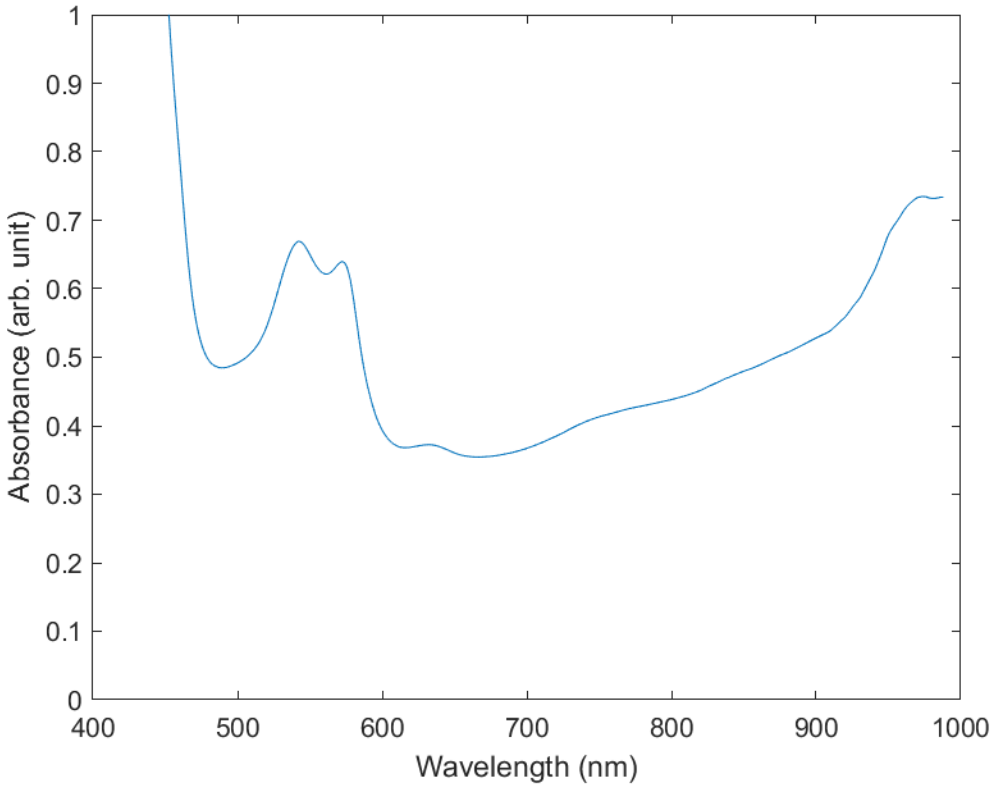
# Measurement setup

Interactance imaging





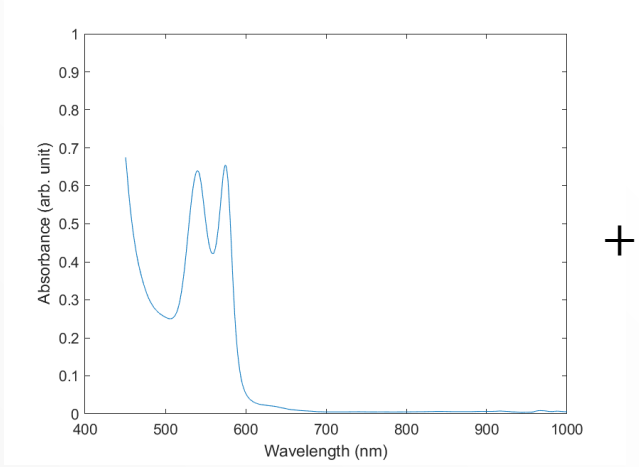
# Constrained spectral unmixing



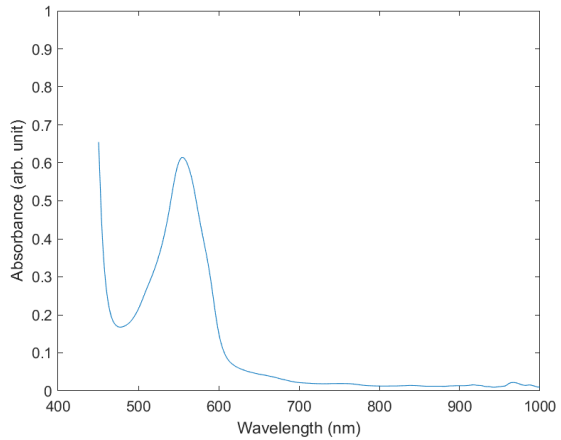



Nofima

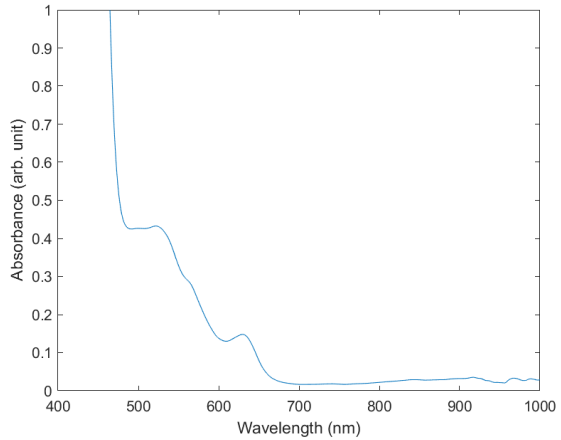
# Constrained spectral unmixing

$a_1 *$ 

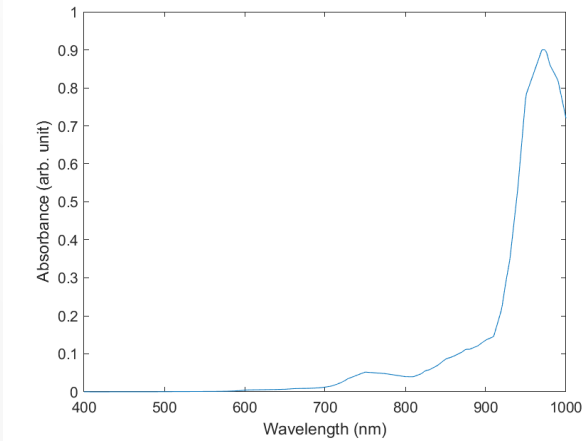

Oxyhaemoglobin

$+ a_2 *$ 


Deoxyhaemoglobin

$+ a_3 *$ 


Methaemoglobin

$+ a_4 *$ 


Water

$+ \quad b_1 + b_2 * \lambda$

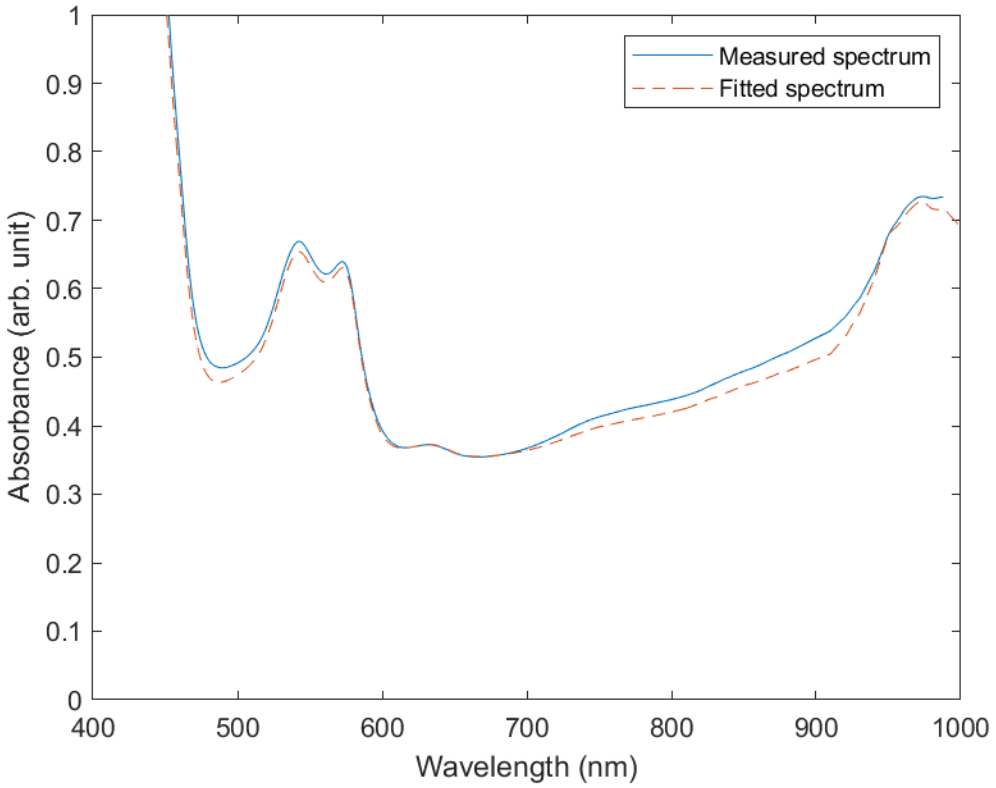
Scattering correction



Nofima

# Constrained spectral unmixing

$a_1$
$a_2$
$a_3$
$a_4$
$b_1$
$b_2$






Nofima

# Constrained spectral unmixing

$a_1$
$a_2$
$a_3$
$a_4$
$b_1$
$b_2$

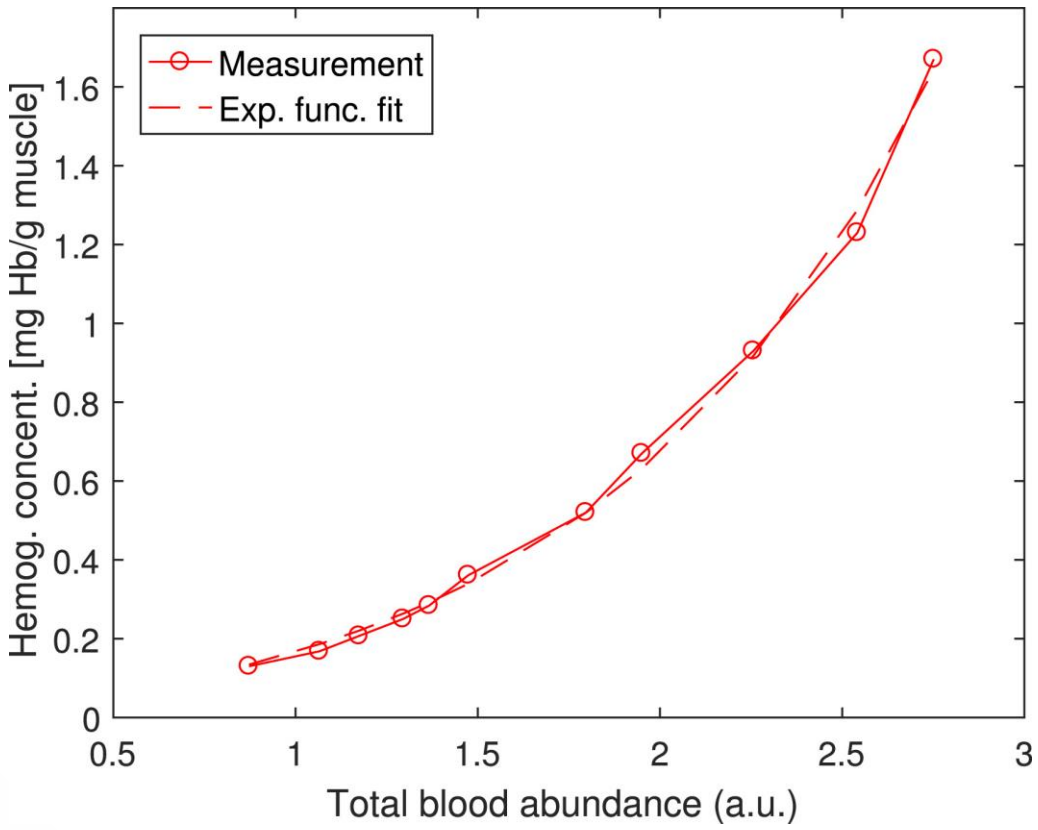
$$a_1 + a_2 + a_3 \quad = total\ blood\ abundance$$



Nofima

# Constrained spectral unmixing

$$f(a_1 + a_2 + a_3)$$



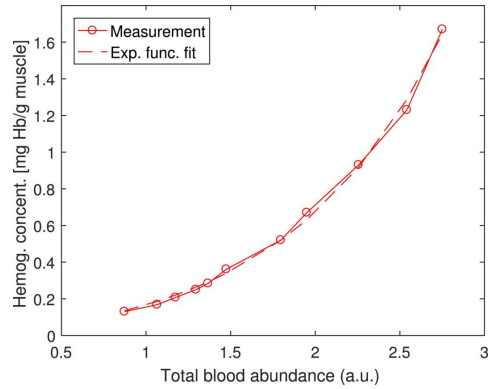

Skjelvareid, M. H., Heia, K., Olsen, S. H. and Stormo, S. K. (2017). *Detection of blood in fish muscle by constrained spectral unmixing of hyperspectral images.* https://doi.org/10.1016/j.jfoodeng.2017.05.029.



Nofima

# Constrained spectral unmixing

$$f(a_1 + a_2 + a_3) = Hemoglobin\ concentration\ \left(\frac{mg\ Hb}{g\ muscle}\right)$$





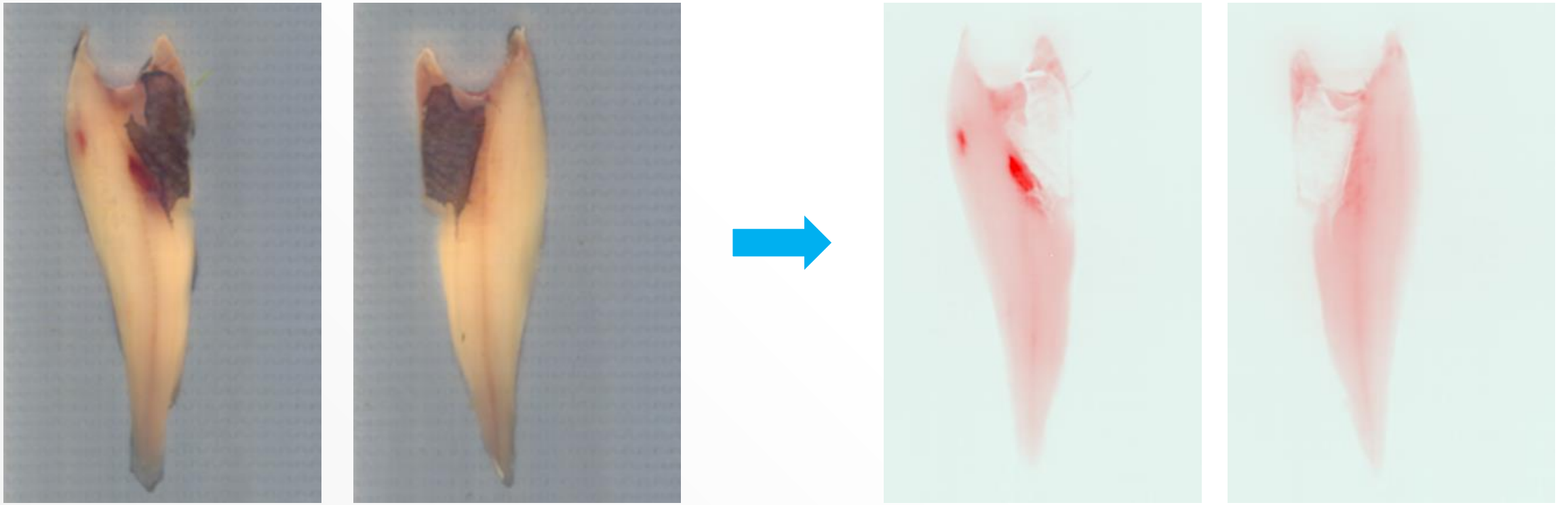

Nofima

# Blood analysis



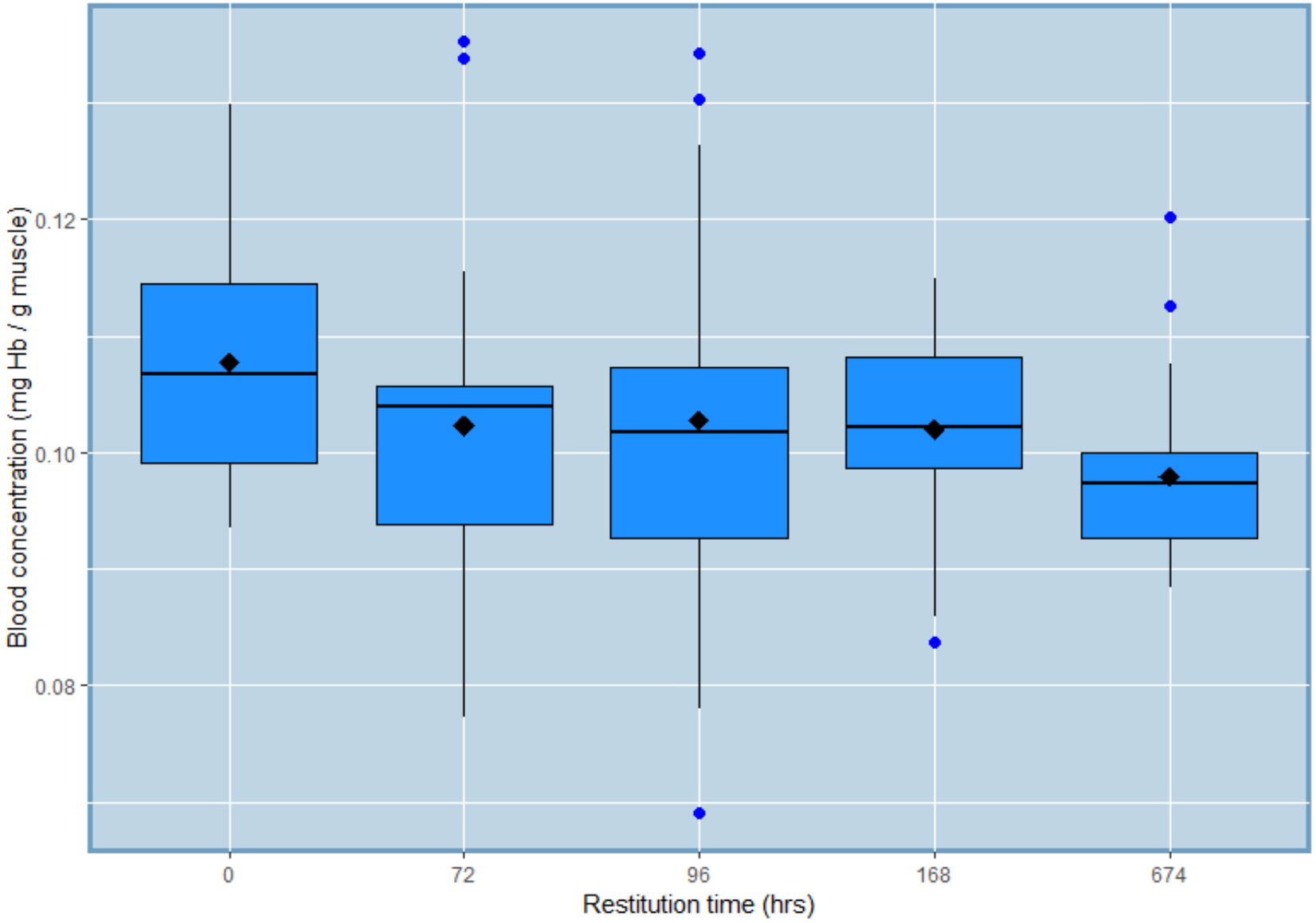
Nofima

# Blood analysis






Nofima


Blood concentration (mg Hb / g muscle)
0.12
0.10
0.08
0
72
96
168
674
Restitution time (hrs)



Nofima

# ANOVA

- $Response = overall\ mean + treatment\ effect + random\ error$
- Null hyphotesis: all treatment effects are equal



Nofima

# ANOVA

- $p\ value$: 0.00917



Nofima

# ANOVA

- $p\ value$: 0.00917

$Shapiro - Wilk\ normality\ test\ on\ residuals$

$p = 0.006676$

$Levene's\ test\ for\ homogeneity\ of\ variance$

$p = 0.06018$



Nofima

# ANOVA

- $p\ value: 0.00917$ ⇒ $Shapiro - Wilk\ normality\ test\ on\ residuals$

  $p = 0.006676$

  $Levene's\ test\ for\ homogeneity\ of\ variance$

  $p = 0.06018$

- $Cohen's\ f: 0.318$ ⇒ *«The standard deviation of the standardized means»*

Cohen, J (1988). *Statistical Power Analysis for the Behavioral Sciences.*

Small effect: $f = 0.10$
Medium effect: $f = 0.25$
Large effect: $f = 0.40$



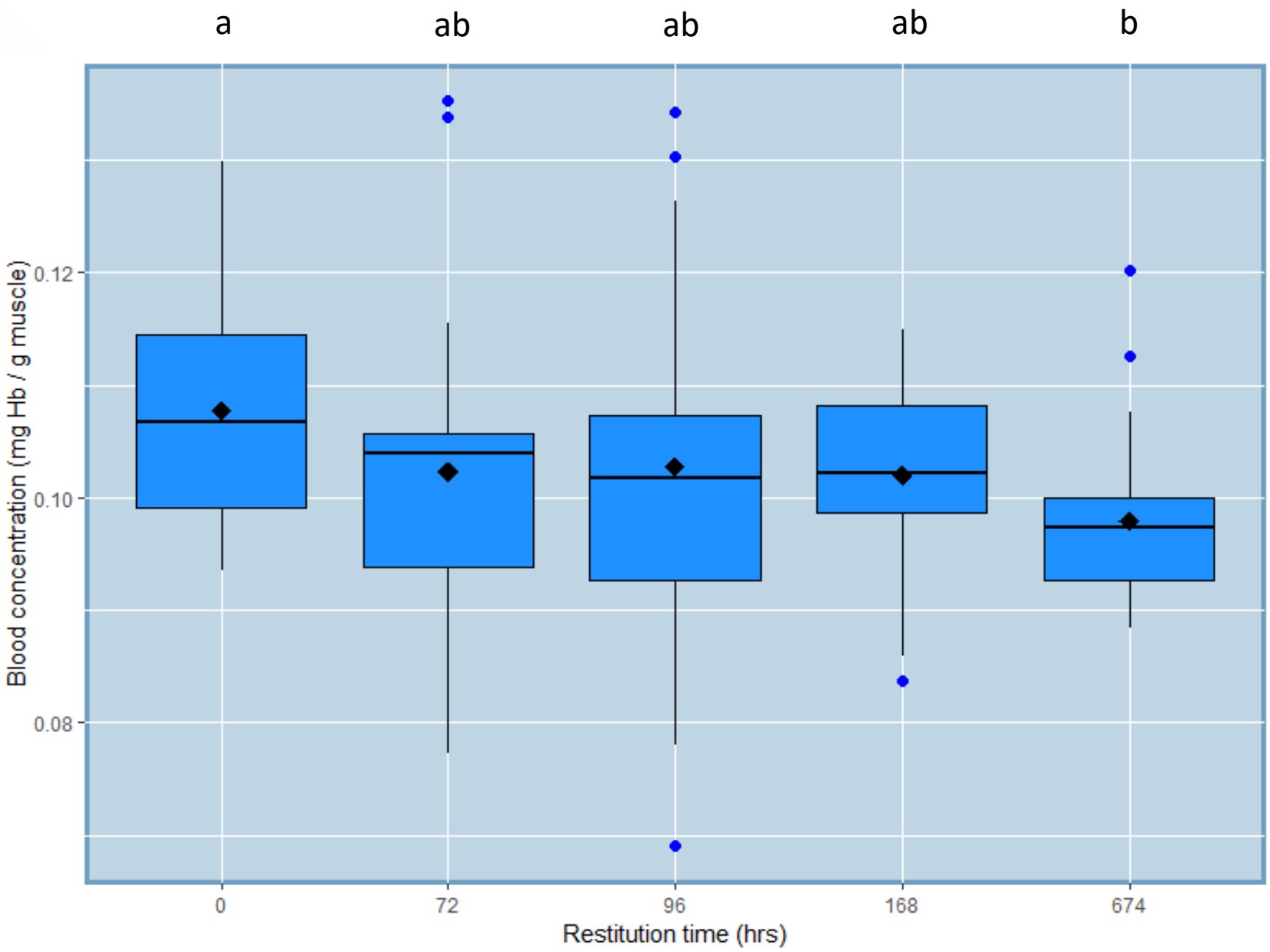
Nofima

# Tukey HSD test

- Pairwise comparison of groups

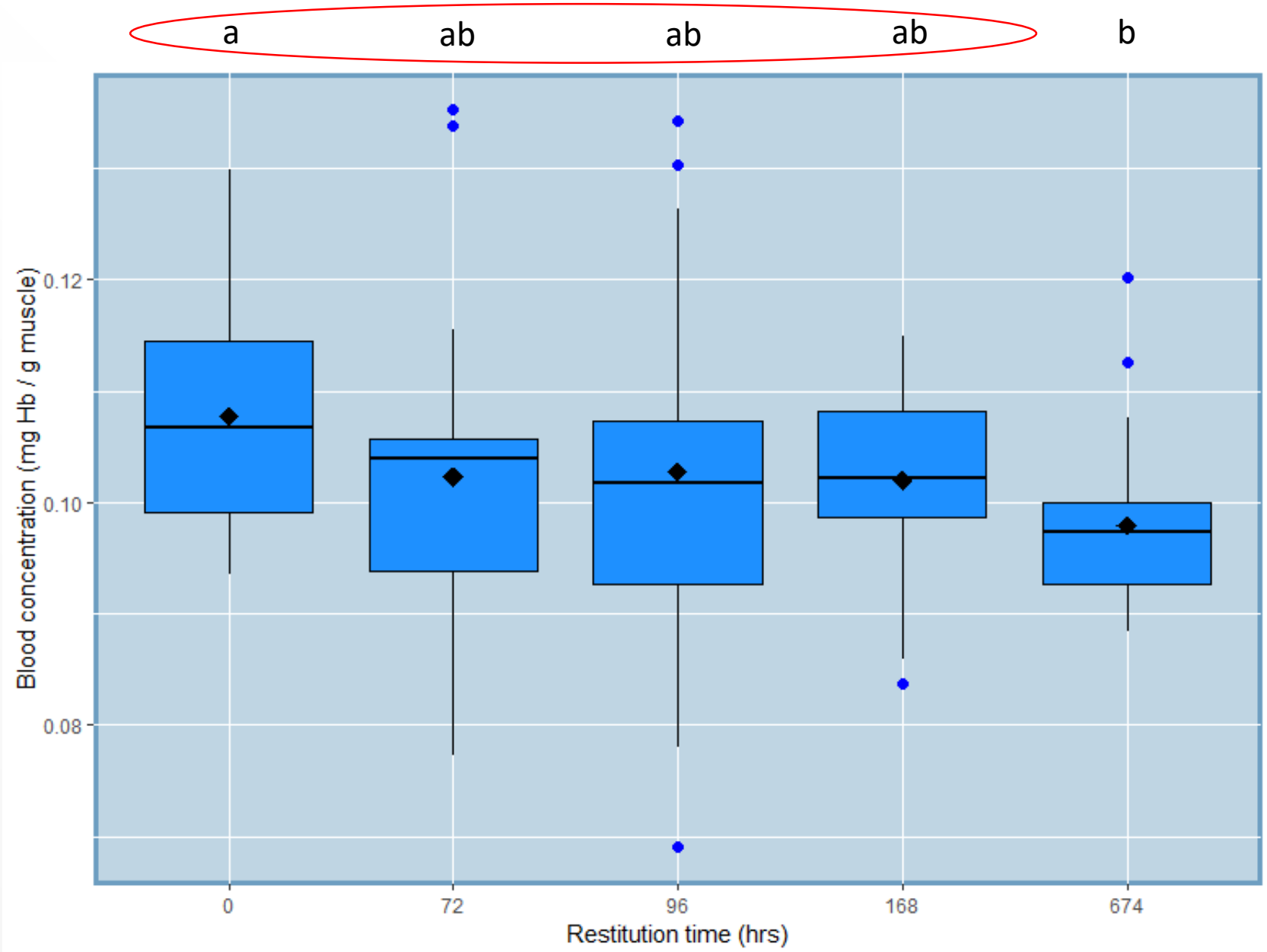


Nofima


a
ab
ab
ab
b
Blood concentration (mg Hb / g muscle)
0.12
0.10
0.08
0
72
96
168
674
Restitution time (hrs)

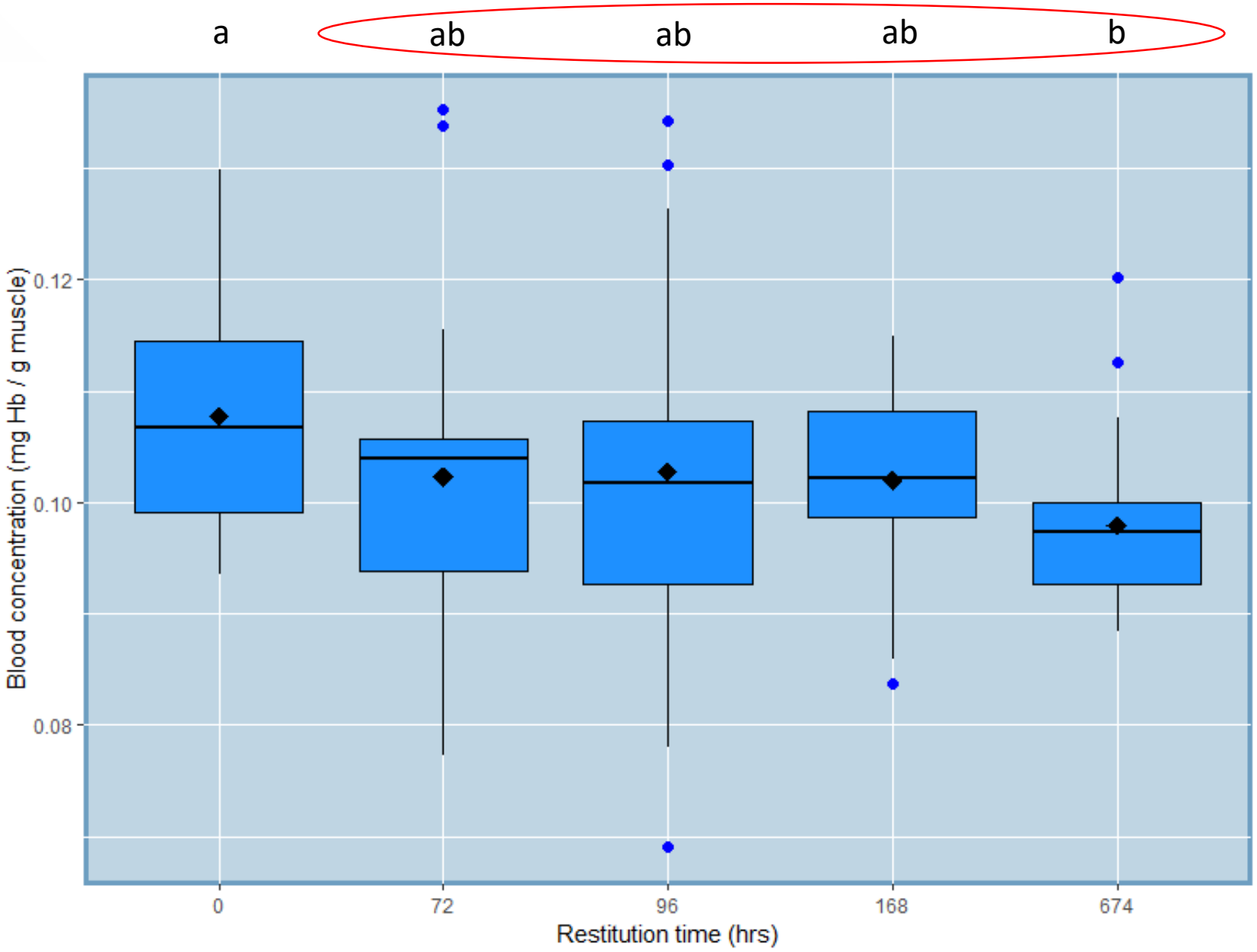


Nofima


a
ab
ab
ab
b
Blood concentration (mg Hb / g muscle)
0.12
0.10
0.08
0
72
96
168
674
Restitution time (hrs)

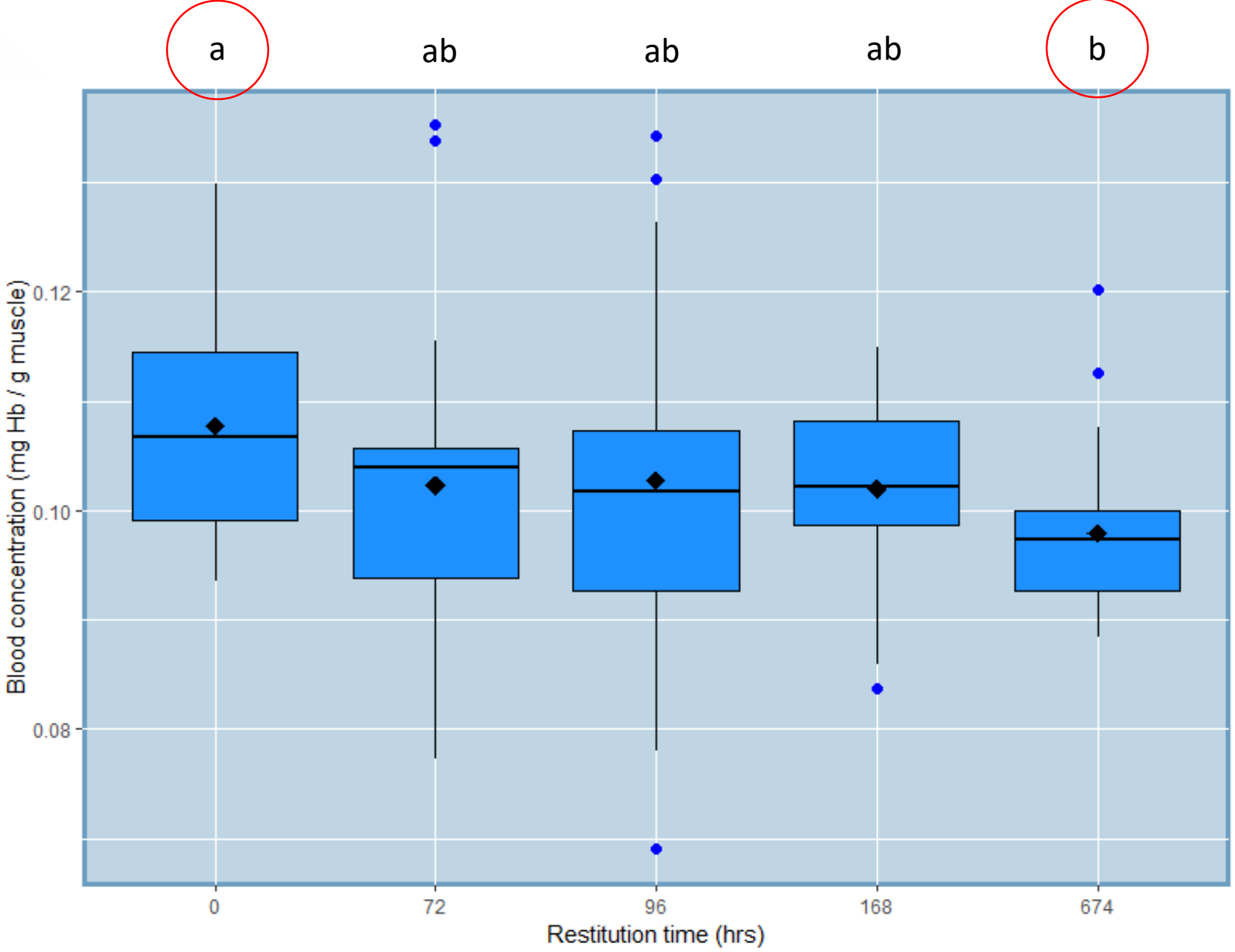


Nofima


a
ab
ab
ab
b
Blood concentration (mg Hb / g muscle)
0.12
0.10
0.08
0
72
96
168
674
Restitution time (hrs)

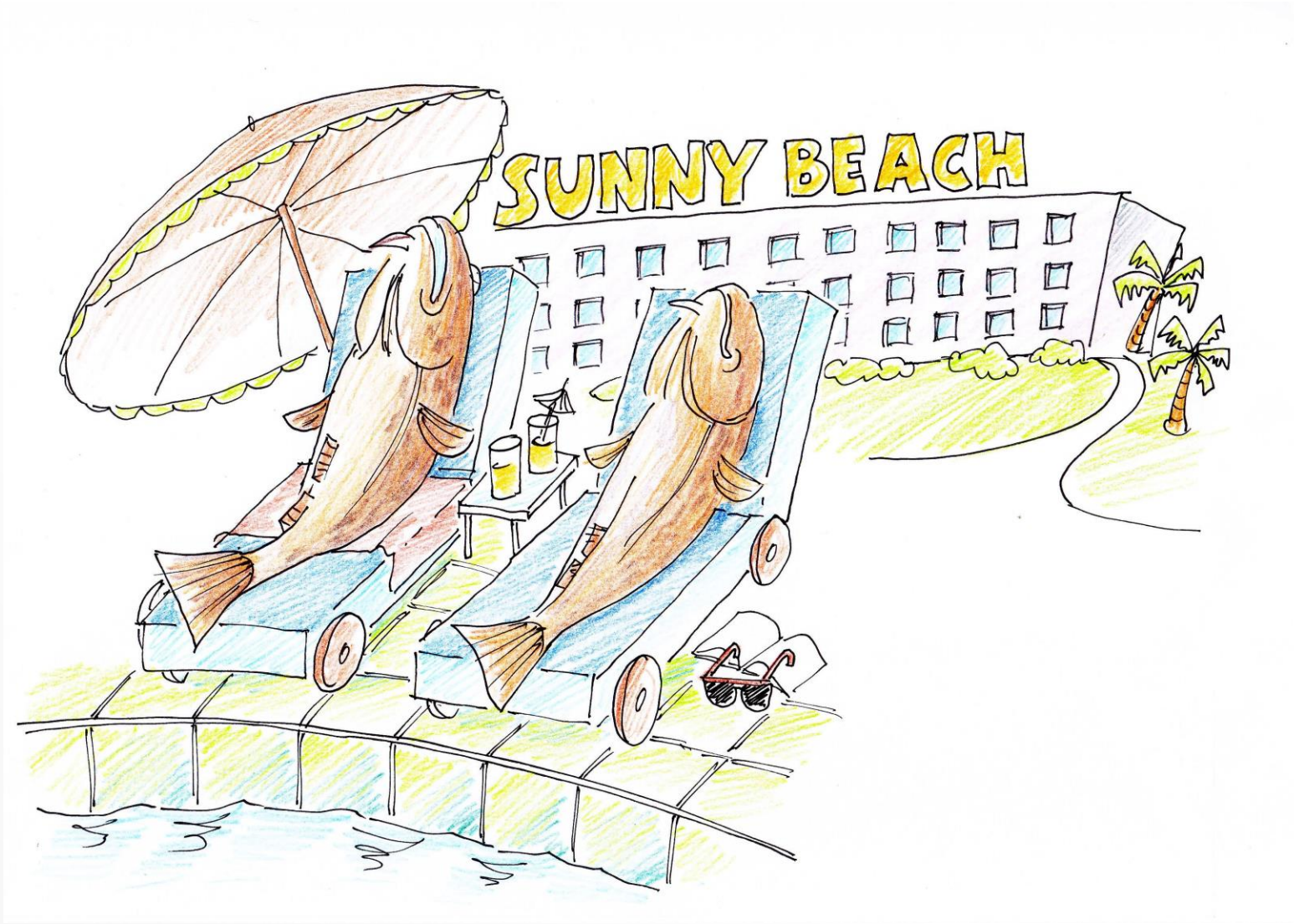


Nofima


a
ab
ab
ab
b
Blood concentration (mg Hb / g muscle)
0.12
0.10
0.08
0
72
96
168
674
Restitution time (hrs)



Nofima



Nofima


facebook.com/nofima/

twitter.com/nofima/

linkedin.com/nofima/

vimeo.com/nofima/

Stein-Kato Lindberg
Scientist

Stein-kato.lindberg@nofima.no

https://nofima.no/person/stein-kato-lindberg/