# EFFECTS OF ALKALINITY AND $CO_2$ ON PACIFIC WHITE SHRIMP *Litopenaeus vannamei* REARED IN BFT SYSTEM

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# MARINE STATION of AQUACULTURE

ESTAÇÃO MARINHA DE AQUACULTURA - FURG
PROJETO CAMARÃO

## Shrimp culture research since 1989

*Courtesy:Paulo Iribarrem*

One of the important points that should be studied is the changes of alkalinity and $CO_2$ in the water of BFT system, due to respiration and nitrification process. Alkalinity and $CO_2$ can also affect shrimp cultured.

The objective of this presentation is to show the most important results achieved during the last two years in Marine Station of Aquaculture, Federal University of Rio Grande, with *L. vannamei* reared BFT systems related with alkalinity and $CO_2$.

1 - Effect of calcium hydroxide, carbonate and sodium bicarbonate on *Litopenaeus vannamei* in BFT systems

# Alkalinity consumption

Zero exchange + Heterotrophic Bacteria + Nitrifying Bacteria

↓ Alkalinity

???

Products for increase alkalinity

McIntoshi, 2001; Boyd et al., 2002; Chen et al. 2006; Furtado et al., 2011

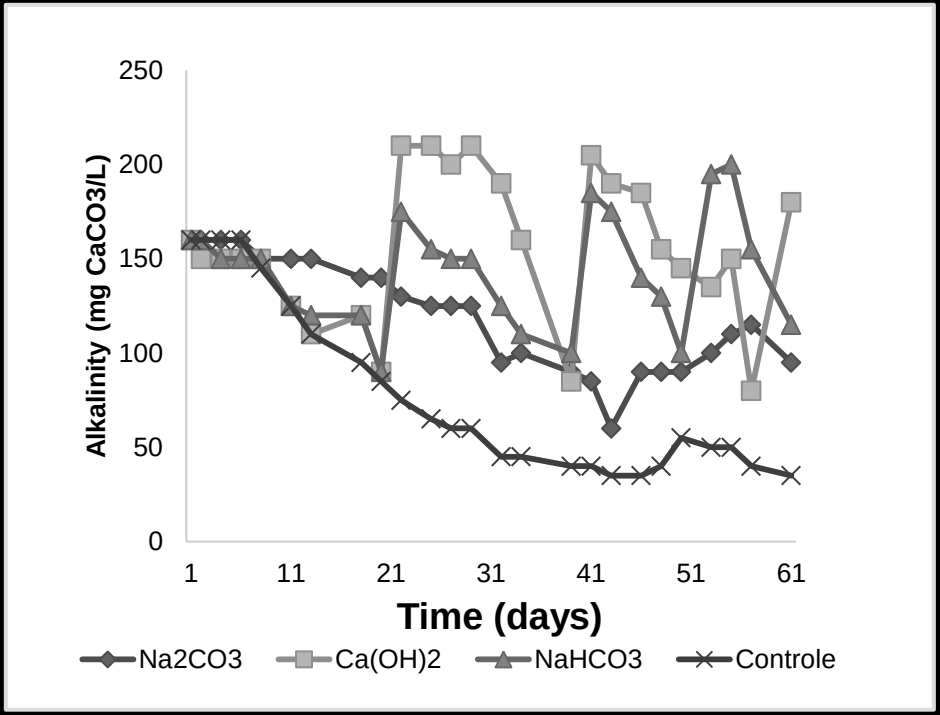
# Methodology

- Juveniles: 6g
- Density: 333 shrimp/$m^3$
- Period: 60 days

## Treatments

| Product | |
|---|---|
| Control | No addition |
| Sodium carbonate or Soda ash | $Na_2CO_3$ |
| Hydrated lime or Slaked lime | $Ca(OH)_2$ |
| Sodium bicarbonate or Baking soda | $NaHCO_3$ |

# Results



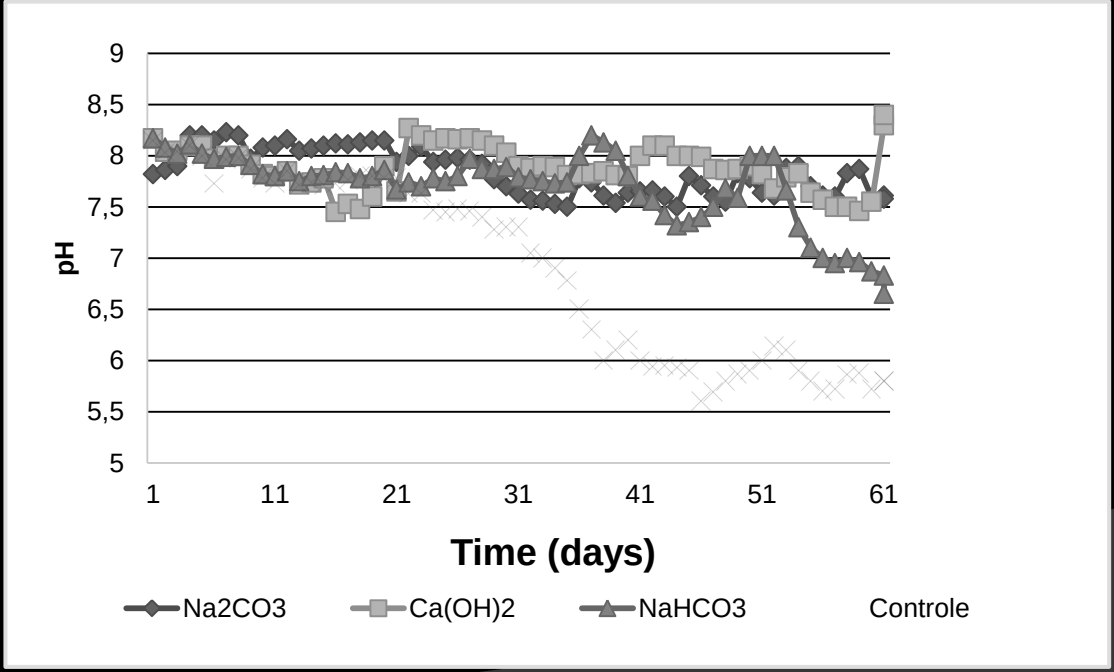

- ✓ Van Wyk & Scarpa (1999) >100 mg $CaCO_3$/L ;
- ✓ Ebeling et al. (2006) 100-150 mg $CaCO_3$/L.

| Parameter | $Na_2CO_3$ | $Ca(OH)_2$ | $NaHCO_3$ | Control |
|---|---|---|---|---|
| Alkalinity (mg $CaCO_3$/L) | $100 \pm 33.9^{C}$ (55-160) | $162.2 \pm 44.9^{A}$ (80-230) | $144.5 \pm 32^{B}$ (80-200) | $78 \pm 47.2^{D}$ (35-160) |

# Results

| Parâmetro | $Na_2CO_3$ | $Ca(OH)_2$ | $NaHCO_3$ | Controle |
|---|---|---|---|---|
| pH | $7.77 \pm 0.53^{AB}$ (7.4-8.25) | $7.90 \pm 0.5^{A}$ (7.25-8.6) | $7.5 \pm 0.46^{B}$ (6.6-8.2) | $6.86 \pm 0.92^{C}$ (5.55-8.15) |

- ✓ Van Wyk & Scarpa (1999) between 7 and 9
- ✓ Wasielesky and browdy (2006) between 7.2 and 8



# Results

Zootechnical parameters of *L. vannamei* juveniles reared during 60-day experimental treatments with correction of pH (T1—$Na_2CO_3$), pH and alkalinity (T2—$Ca(OH)_2$), alkalinity (T3—$NaHCO_3$) and without correction of pH and alkalinity (T4—control).

| Parameters | T1—$Na_2CO_3$ | T2—$Ca(OH)_2$ | T3—$NaHCO_3$ | T4—control |
|---|---|---|---|---|
| Survival (%) | $83.3 \pm 3.0$ | $85.0 \pm 7.0$ | $80.0 \pm 2.7$ | $80.0 \pm 2.8$ |
| Initial weight (g) | $5.6 \pm 0.9$ | $5.8 \pm 0.9$ | $5.6 \pm 0.7$ | $5.8 \pm 1.1$ |
| Final weight (g) | $15.0 \pm 1.3^{A}$ | $14.3 \pm 1.4^{B}$ | $14.2 \pm 1.6^{B}$ | $12.0 \pm 1.5^{C}$ |
| Weight gain (g) | $9.3 \pm 1.2^{A}$ | $8.4 \pm 1.5^{AB}$ | $8.5 \pm 0.1^{B}$ | $6.2 \pm 0.2^{C}$ |
| Final biomass (g) | $630.0 \pm 61.1^{A}$ | $615.7 \pm 9.3^{A}$ | $570.8 \pm 7.2^{B}$ | $480.0 \pm 17.8^{C}$ |
| Weight gain/week (g/week) | $1.1 \pm 0.2^{A}$ | $1.0 \pm 0.1^{A}$ | $1.0 \pm 0.1^{A}$ | $0.7 \pm 0.1^{B}$ |
| Feed conversion rate | $1.4 \pm 0.2^{A}$ | $1.4 \pm 0.1^{A}$ | $1.5 \pm 0.1^{A}$ | $3.0 \pm 0.3^{B}$ |
| Productivity ($kg/m^3$) | $2.3 \pm 0.1^{A}$ | $2.2 \pm 0.1^{A}$ | $1.8 \pm 0.1^{B}$ | $1.3 \pm 0.5^{C}$ |

The data correspond to the mean of 3 replicates ± standard deviation. Different superscripts in the same row indicate that the means, significantly, differ ($P<0.05$).

# Conclusion

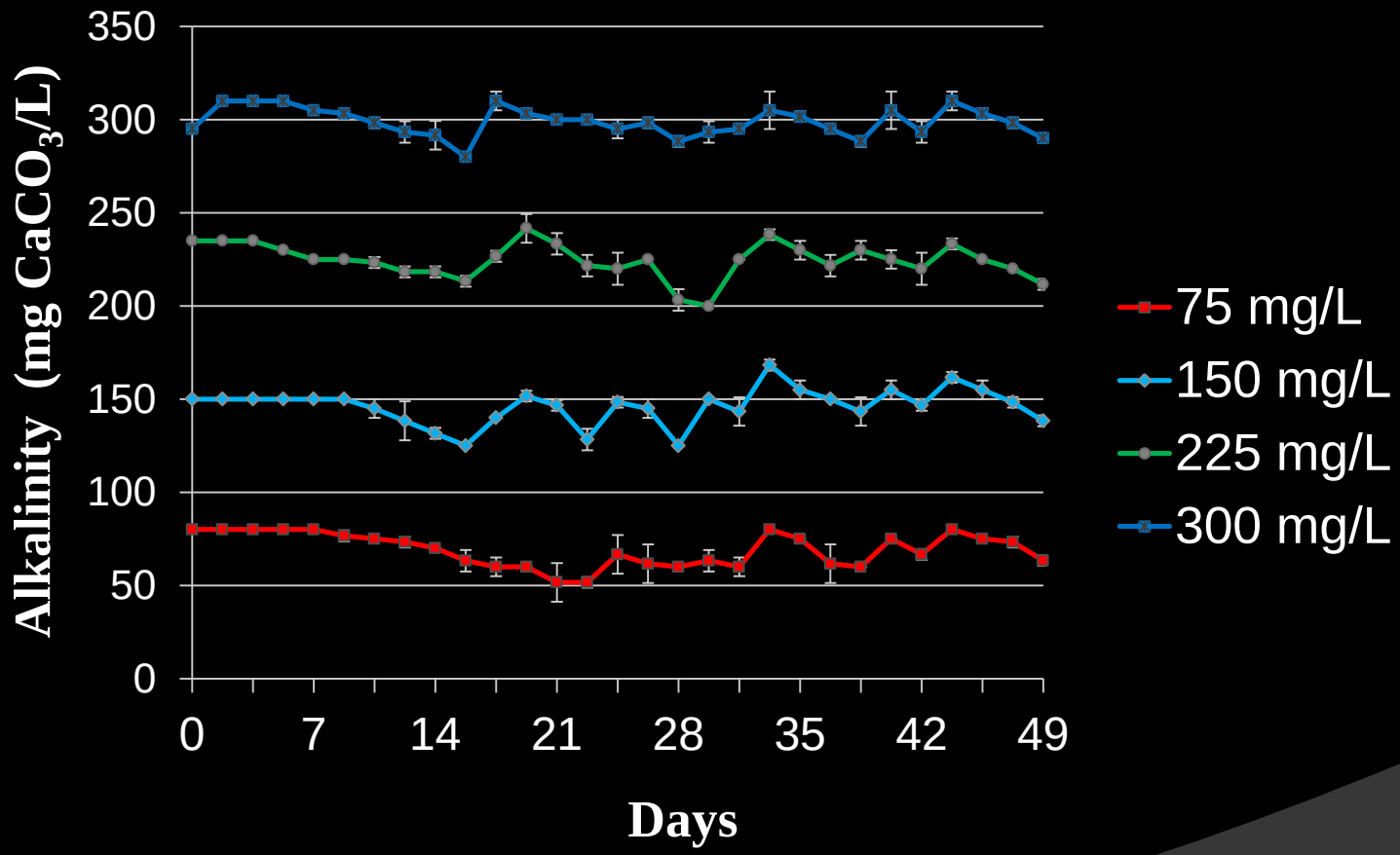
- Sodium carbonate ($Na_2CO_3$), sodium bicarbonate ($NaHCO_3$) and calcium hydroxide ($Ca(OH)_2$) were good for water quality, biofloc development and shrimp performance. However calcium hydroxide is more cost-effective than other products.

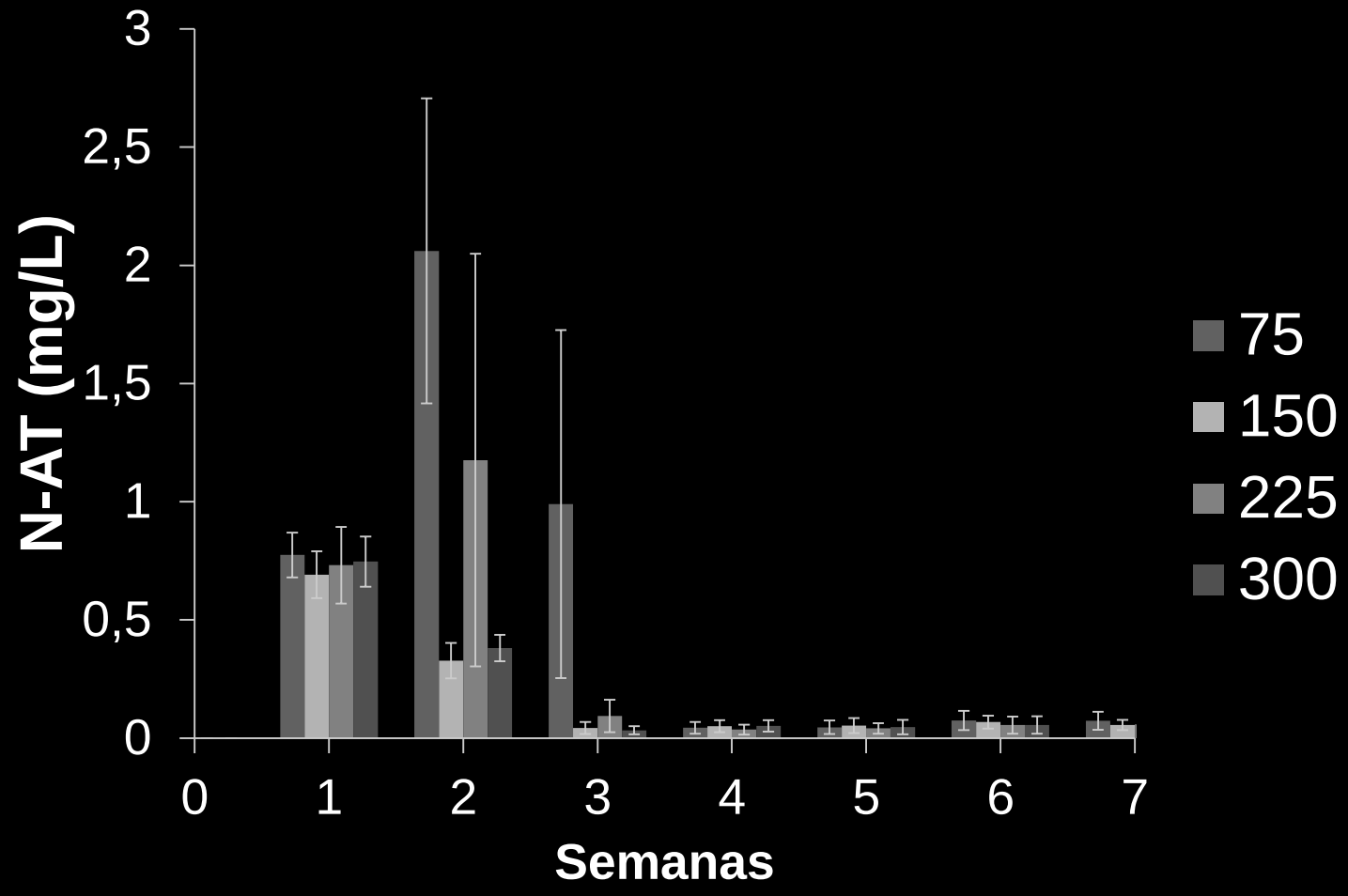
# 2 – The effect of different alkalinity levels on *L. vannamei* BFT culture

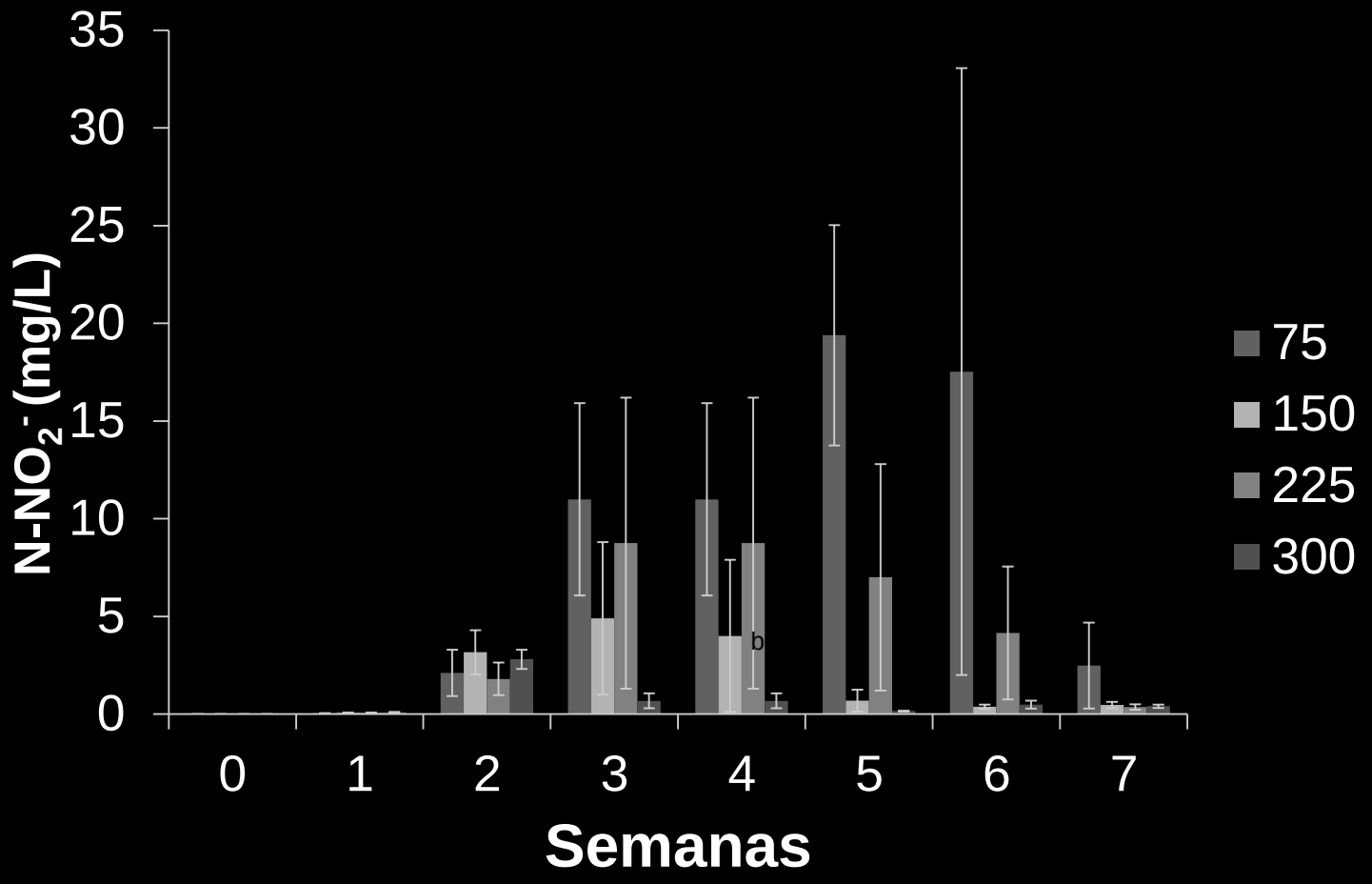
# Methodology

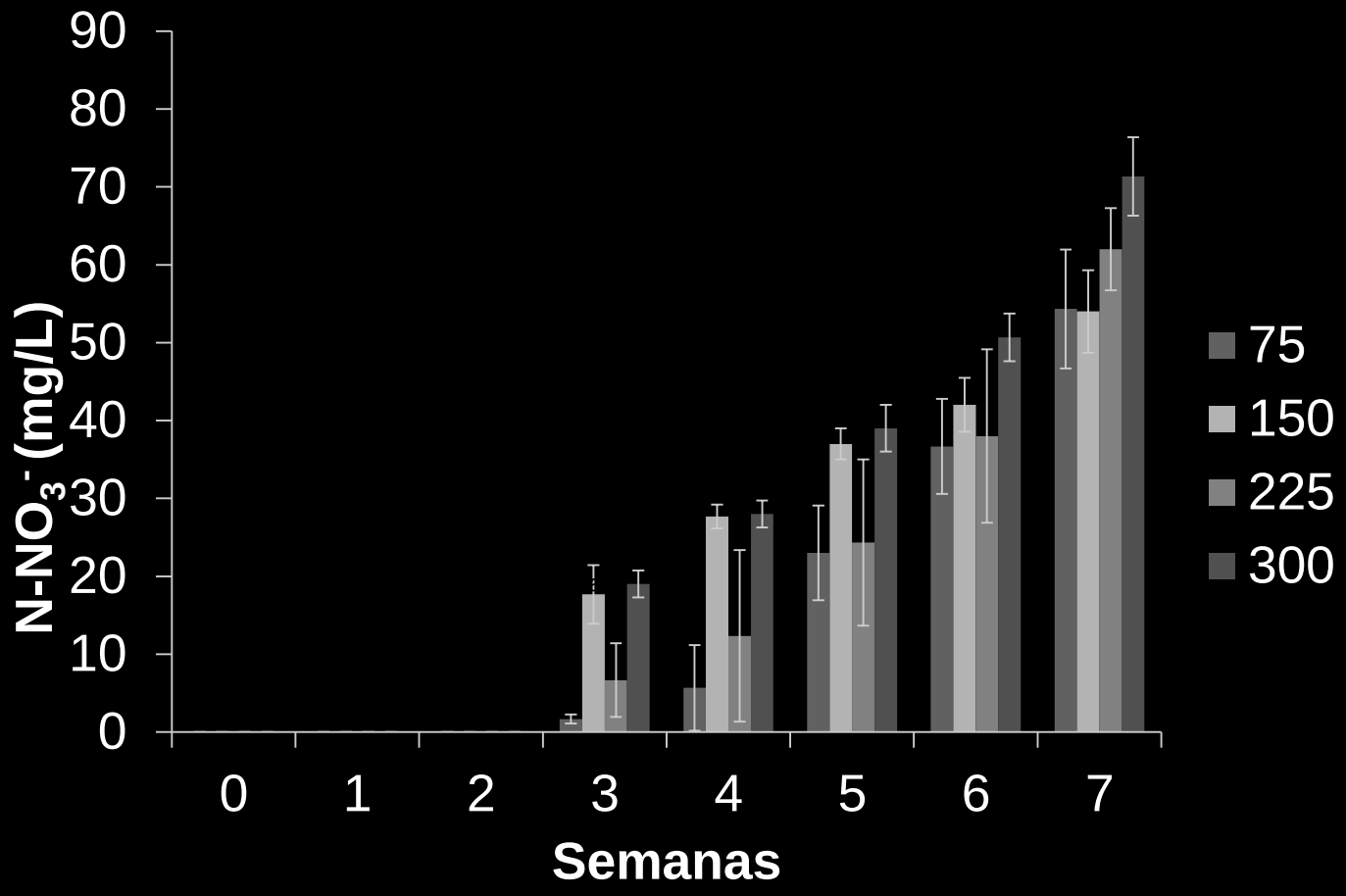
- Alkalinity levels - 75, 150, 225 and 300 mg/L $CaCO_3$;
- No Inoculation of biofloc
- 12 Tanks of 150 L
- 150 shrimp per $m^2$
- Initial weight: 0.2 g
- Water quality: Tem, sal, N-AT, N-NO2, N-NO3, Alk, pH, CO2, TSS, SV
- Period: 7 weeks

# Results


Alkalinity (mg $CaCO_3$/L)
350
300
250
200
150
100
50
0
0
7
14
21
28
35
42
49
Days
75 mg/L
150 mg/L
225 mg/L
300 mg/L


N-AT (mg/L)
3
2,5
2
1,5
1
0,5
0
0
1
2
3
4
5
6
7
Semanas
75
150
225
300


35
30
25
20
15
10
5
0
N-NO2- (mg/L)
0
1
2
3
4
5
6
7
Semanas
b
75
150
225
300


90
80
70
60
50
40
30
20
10
0
N-NO3- (mg/L)
0
1
2
3
4
5
6
7
Semanas
75
150
225
300

| Parameter | 75 | 150 | 225 | 300 |
|---|---|---|---|---|
| Survival (%) | 90.00± 3.3 | 88.00 ± 3.85 | 92.12 ± 5.30 | 91.22 ± 2.92 |
| Initial Weight (g) | 0.20± 0.07 | 0.20 ± 0.07 | 0.20 ± 0.07 | 0.20 ± 0.07 |
| Final Weight final (g) | 4.78± 0.12$^{A}$ | 5.34 ± 0.31$^{AB}$ | 4.95 ± 0.23$^{AB}$ | 5.44 ± 0.42$^{B}$ |
| Weight Gain (g) | 4.57± 0.13$^{A}$ | 5.13 ± 0.34$^{AB}$ | 4.74 ± 0.30$^{AB}$ | 5.24 ± 0.42$^{B}$ |
| FCR | 1.15 ± 0.08$^{A}$ | 1.10 ± 0.08$^{A}$ | 1.11 ± 0.05$^{A}$ | 1.08 ± 0.07$^{A}$ |

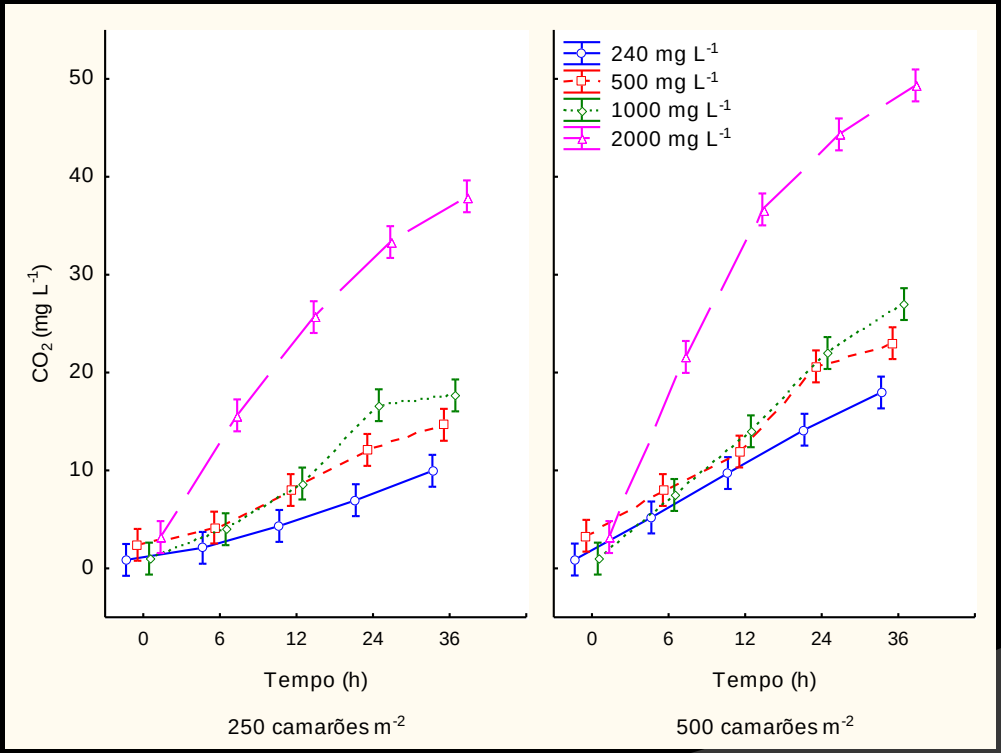
# Conclusions

1. The best nitrification rate were in higher alkalinity treatments, probably due to higher inorganic carbon availability.
2. Ammonia and nitrite had lower spikes in 225 and 300 mg/L $CaCO_3$.
3. Then, better shrimp zootechnical performance were detected in 225 and 300 mg/L $CaCO_3$.

# 3 – Acute effect of $CO_2$ on *Litopenaeus vannamei* juveniles

- According to Furtado el al 2012, when a BFT system are stocking densities up to 500 shrimp per $m^2$ and total suspended solids are up to 2000mg/L, $CO_2$ can achieve high concentration (up to 50mg/L).

- This CO2 concentration can provoke mortalities???

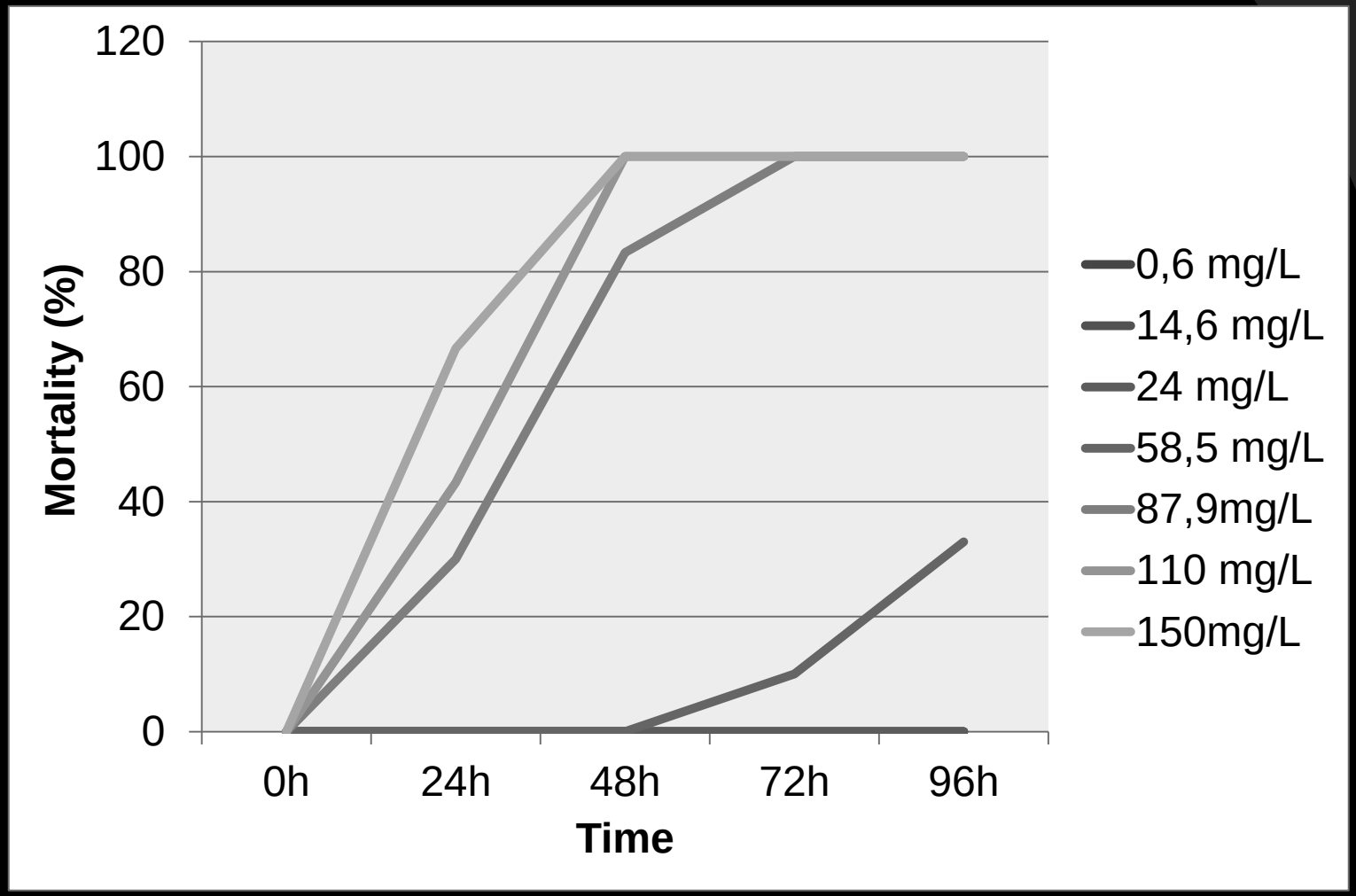


# Methodology - Dissolved $CO_2$

- Treatments: control (no $CO_2$ addition), 14.6, 24.0, 58.50, 110.0 and 150.0 mg/L
- $CO_2$ monitoring: Probe and calculating through pH and Alkalinity (Timmons and Ebeling)

# Methodology

- ✓ 30 juveniles (2,01±0,30g)
- ✓Clear water
- ✓Temperature 27ºC
- ✓Salinity 30‰
- ✓40 L tanks
- ✓3 replics
- ✓$LC_{50}$ 24 and 96 hours
- ✓$LC_{50}$TSKM




Higher concentration that did not present mortality in different period.

24h = 58.5mg/L; 48h = 58.5mg/L; 72h = 24.0mg/L; 96h = 24.0 mg/L

# $CO_2$ Results

$CO_2$ $CL_{50}$ – 24h

119.96 mg/L (83.21-172.95)

$CO_2$ $CL_{50}$ – 96h

62.24 mg/L (54.6-70.95)

Estimated safe level = 6.22 mg/L

- ✓ Van Wyk & Scarpa (1999):

| | |
|---|---|
| < 5 mg/L | suitable |
| 5-20 mg/L | acceptable |
| 20-60 mg/L | Chronic effects |
| >60 mg/L | Lethal |

# Conclusion

$CO_2$ should be monitored in order to check if concentrations are below than 6,22 mg/L for better shrimp survival and performance, mainly in BFT systems.

# 3 – The use of different amount of calcium hydroxide on *L. vannamei* culture

# Experimental design

In this experiment was analyzed the effect of addition of 10%, 20%, and 40% of calcium hydroxide, equivalent of the weight of supplied feed.

- Tratamento controle (TC) teve o nível de pH >7,2 (0,05 g/L de $Ca(OH)_2$);
- Treatment 10% (T10);
- Treatment 20% (T20);
- Treatment 40% (T40).

# Experimental units - Methodology

- 12 tank (150 L/tq)
- Inoculum of biofloc: 30%
- Feeding: 40% CP (2x/day)
- 85 juveniles (0,18±0,06 g)
- Density: 425 cam/$m^3$
- Water quality: Tem, sal, N-AT, N-NO2, N-NO3, Alk, pH, CO2, TSS, SV
- Period: 56 dias

# Results

| | Tratamentos | | | |
|---|---|---|---|---|
| | **TC** | **T10** | **T20** | **T40** |
| **Temperature (ºC)** | 27,82 ± 0,81 | 28,18 ± 0,83 | 28,21 ± 0,75 | 27,85 ± 0,71 |
| **Salinity** | 25,84 ± 1,42 | 25,78 ± 1,24 | 25,84 ± 1,36 | 25,75 ± 1,30 |
| **DO (mg /L)** | 6,08 ± 0,10 | 6,01 ± 0,15 | 6,02 ± 0,13 | 6,09 ± 0,11 |

Wyban et al. (1995)

Maicá et al. (2012)

Van Wyk & Scarpa (1999)

OK!

## Treatments

| | TC | T10 | T20 | T40 |
|---|---|---|---|---|
| **SST (mg/L)** | 963.60 ± 383.96 | 995.72±333.43 | 998.53±397.16 | 924.37± 365.,91 |
| **TAN (mg/L)** | 0.08 ± 0.06$^{A}$ | 0,08 ± 0,09$^{A}$ | 0,10 ± 0,09$^{A}$ | 0,28 ± 0,68$^{B}$ |
| **$NO_2^-$ N (mg /L)** | 0,07 ± 0,03 | 0,07 ± 0,05 | 0,08 ± 0,05 | 0,09 ± 0,08 |
| **$NO_3^-$ N (mg /L)** | 48,92 ± 23,53 | 53,05 ± 25,87 | 49,66 ± 24,20 | 44,91 ± 19,92 |
| **$PO_4^{3-}$-P (mg/L)** | 1,06 ± 0,38 | 1,11 ± 0,50 | 1,07 ± 0,49 | 1,10 ± 0,43 |

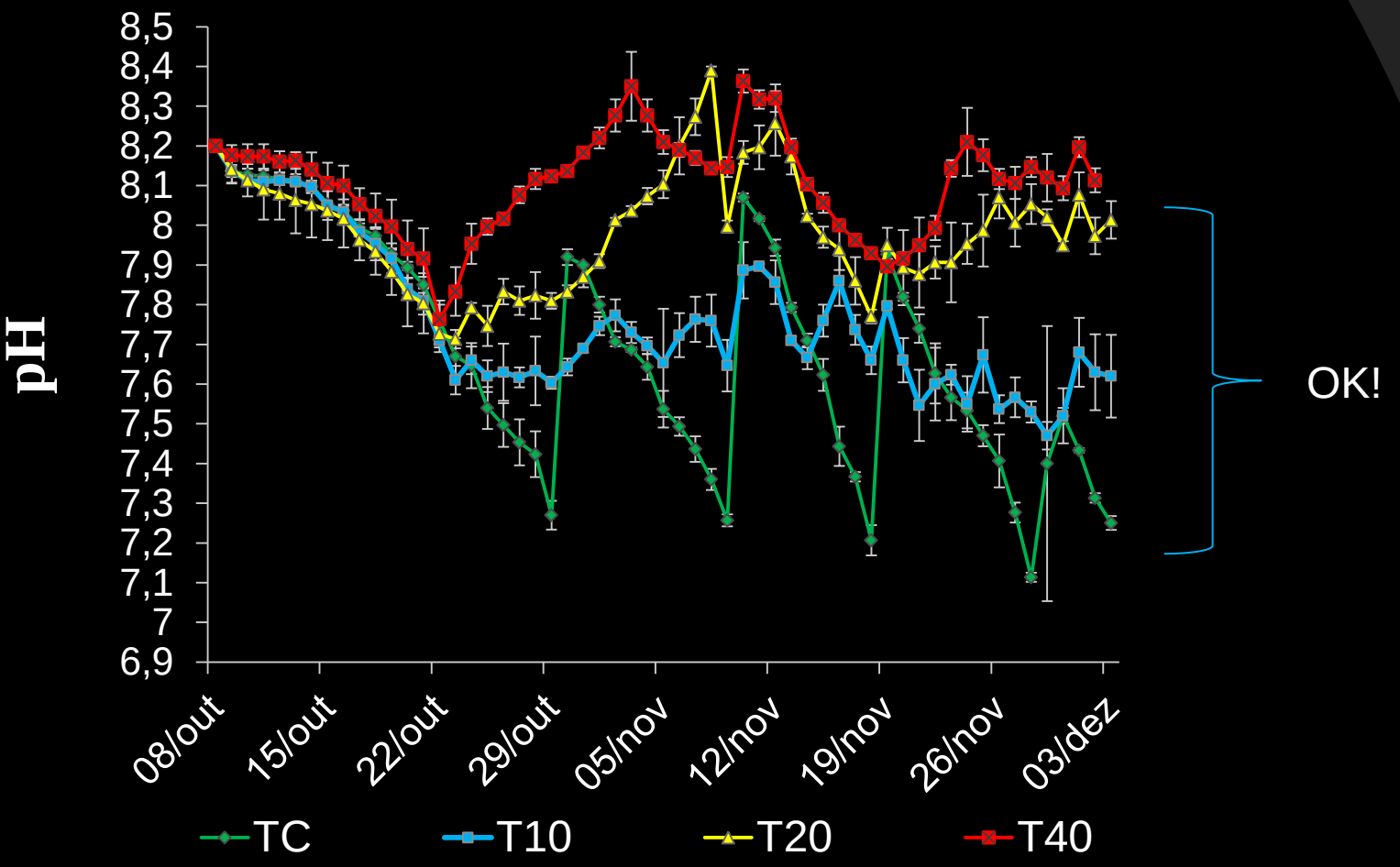
Gaona et al. (2011)

Lin & Chen (2001, 2003)

Kuhn et al. (2010)

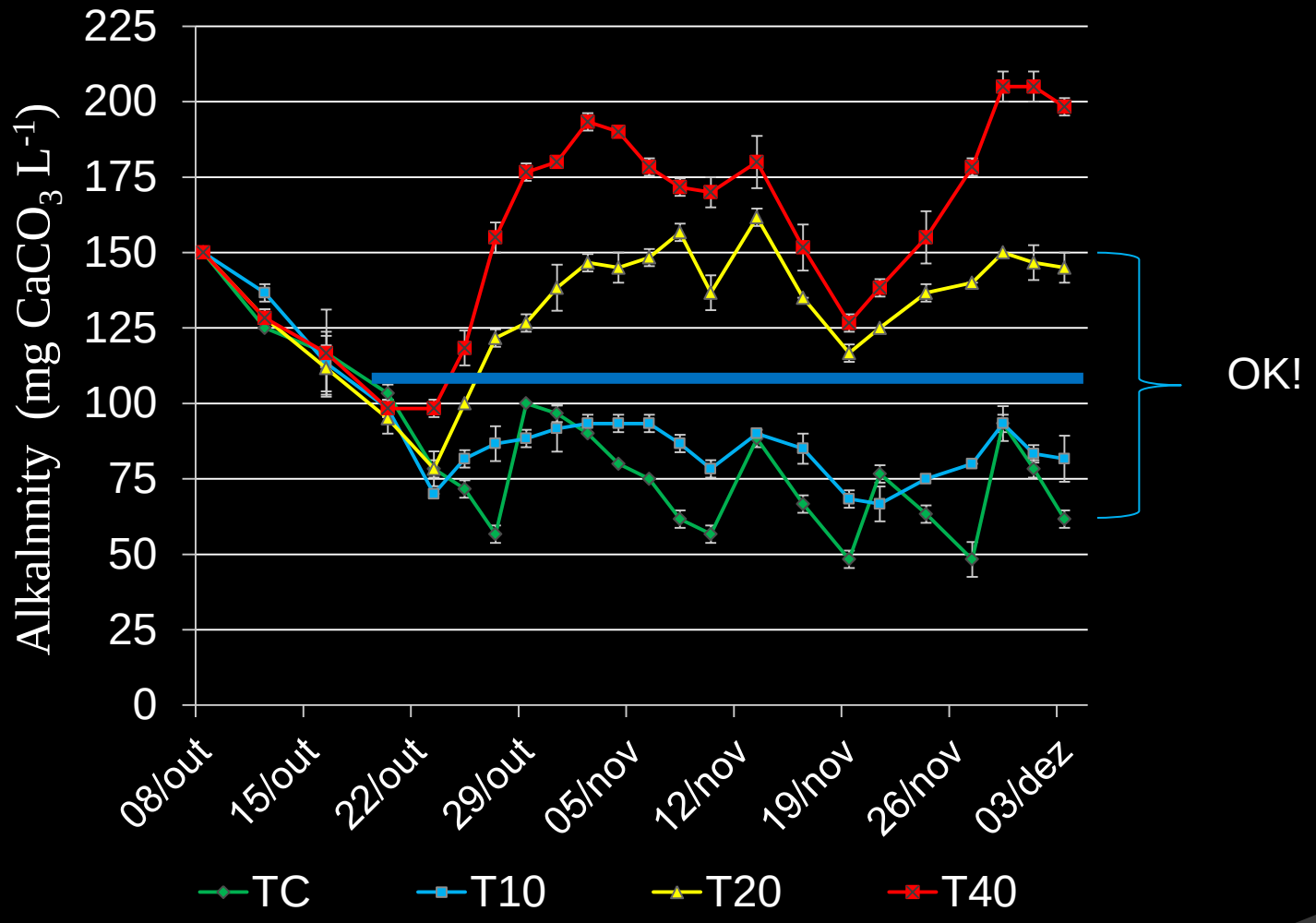
Wasielesky et al. (2006)

OK!




| | | | |
|---|---|---|---|
| $7,68 \pm 0,20^{A}$ | $7,76 \pm 0,12^{A}$ | $7,98 \pm 0,11^{B}$ | $8,14 \pm 0,16^{C}$ |

Van Wyk & Scarpa (1999)




| | | | |
|---|---|---|---|
| $82,05 \pm 25,51^{A}$ | $90,65 \pm 20,04^{A}$ | $132,17 \pm 20,9^{B}$ | $159,27 \pm 32,82^{C}$ |

Van Wyk & Scarpa (1999)

| Parameters | Treatments | | | |
|---|---|---|---|---|
| | TC | T10 | T20 | T40 |
| Survival (%) | 92,15 ± 3,96 | 91,76 ± 4,07 | 93,72 ± 5,19 | 85,03 ± 3,13 |
| Initial Weight (g) | 0,18 ± 0,06 | 0,18 ± 0,06 | 0,18 ± 0,06 | 0,18 ± 0,06 |
| Final Weight (g) | 4,28 ± 1,34$^{A}$ | 4,38 ± 1,31$^{A}$ | 4,09 ± 1,30$^{A}$ | 3,08 ± 1,01$^{B}$ |
| FCR | 1,25 ± 0,04$^{A}$ | 1,24 ± 0,05$^{A}$ | 1,30 ± 0,13$^{A}$ | 1,79 ± 0,07$^{B}$ |
| Productivity (kg/m$^3$) | 2,12 ± 0,12$^{A}$ | 2,15 ± 0,10$^{A}$ | 2,09 ± 0,2$^{A}$ | 1,45 ± 0,05$^{B}$ |

Krummenauer et al. (2011)

~1,29

Baloi et al. (2013)

~2,20 kg/m²

# Conclusions

✓ For alkalinity and pH correction it can be applied 0.05 g/L of $Ca(OH)_2$, when pH achieve 7.2;

✓ The correction can be done applying 10-20% of $Ca(OH)_2$, according of the amount of supplied food.

# ACKNOWLEDGEMENTS











Thanks for your attention!
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