FEED TECHNO VISION 2024

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Enzymatic hydrolysis – improving water stability of the shrimp feed

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NMBU

trouw nutrition
a Nutreco company

Importance of water stability in shrimp feed: Overview of enzymatic hydrolysis as a solution

- Pelleting
- Water stability for the shrimp pellets
- Enzymatic hydrolysis – benefits in digestibility and physical quality
- Improved digestibility and reduced leaching of nutrients
- Decreased water solubility and environmental impact
- Future perspectives

Pelleting

Granulation conditions and moisture

Specifications and condition of equipment

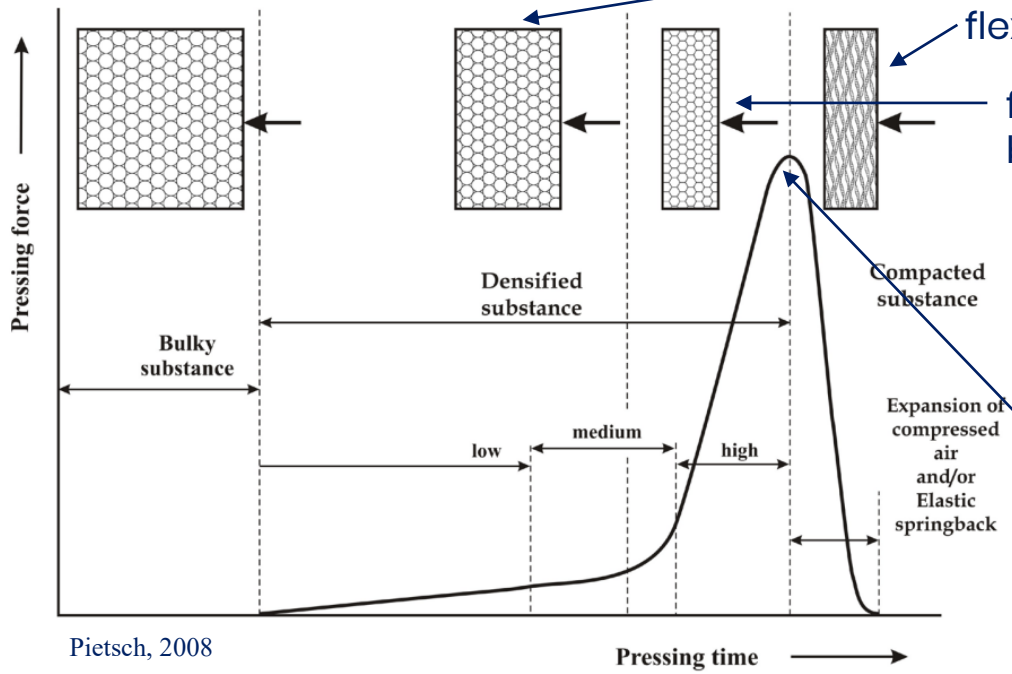
Particle size

Pellet quality

Raw materials

↓FCR ↑ADC ↑ADG → DC - daily feed consumption; DG - daily gain

The Mechanism of Pelleting and its Rheology



Pietsch, 2008

Pressure Agglomeration

a forced rearrangement of particles requiring little pressure

flexible particles deform plastically

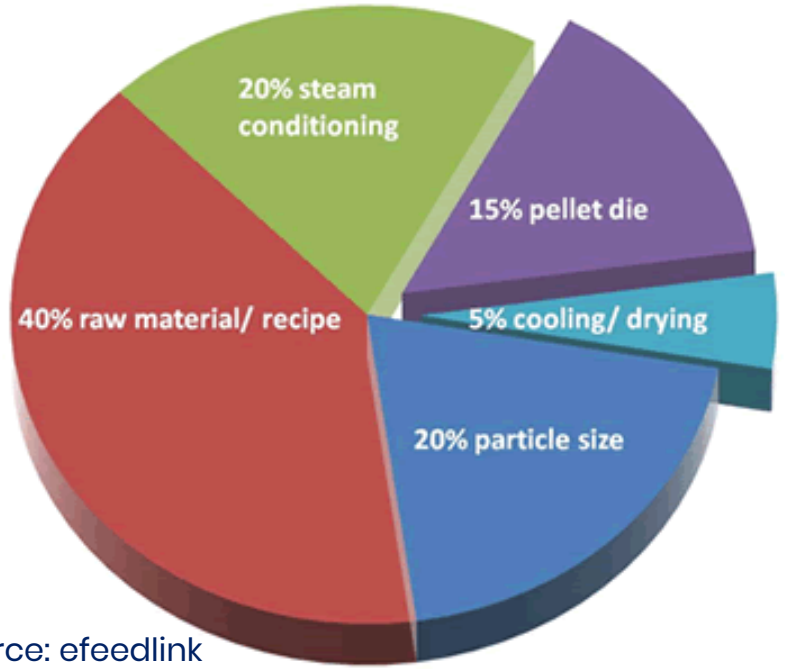
followed by a steep pressure rise during which brittle particles break

– ***pMax –*** *Pressure at initial flow measurement (electrical consumption due to the viscosity of the deformed material in the pelleting die)*

Challenges in the Feed Manufacturing

- Ensuring consistent nutritional content with the correct technology;
- Cost-effective raw materials;
- Quality control issues - Preserving the technical quality of pellets:
  - Hardness (tensile stress)
  - Durability (attrition, feeding, deterioration)
  - Density (sinking)
  - Water stability

Influencing factor (technical quality)

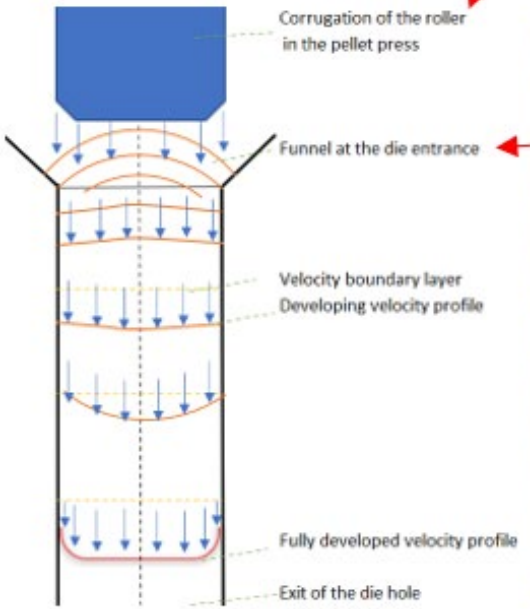


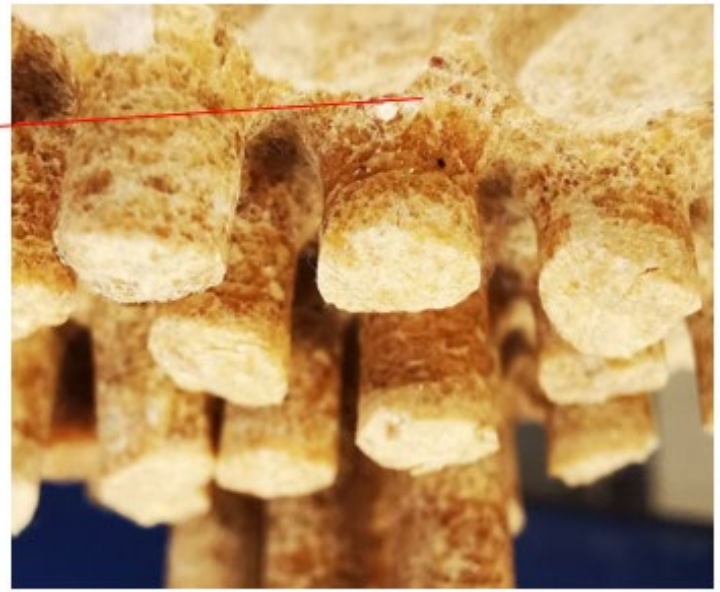
Source: efeedlink

The question that is often asked is...

A pile of pellets or... A valuable pile of pellets?

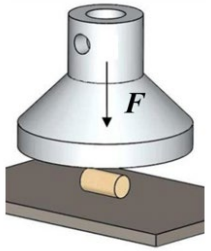
Quality Control Measurements



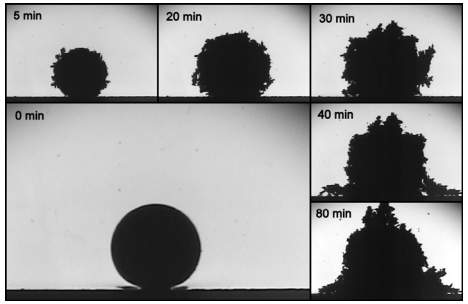


Pelleting

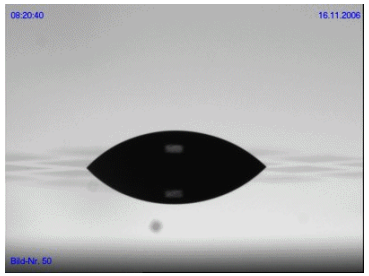
Tensile strength →

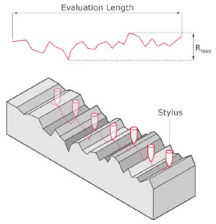


Water stability →



Contact angle →





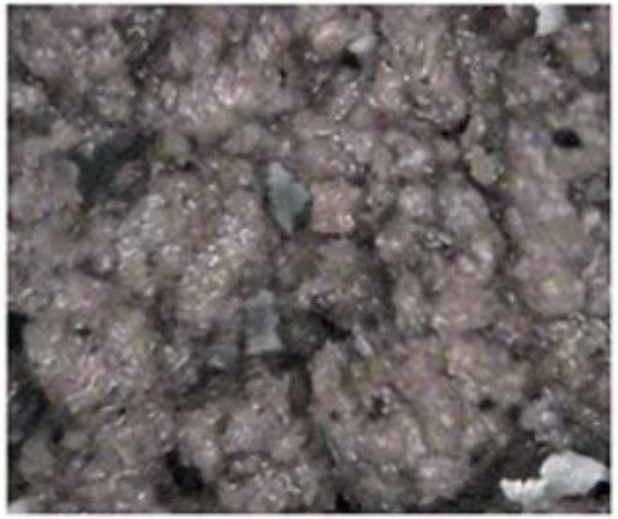
→ **Surface roughness**

Analyses

Understanding Water Stability

- Definition of water stability (WS) in shrimp feed:
  - High WS ensures that the feed pellets do not disintegrate rapidly upon contact with water

Control Feed (No Binder)



After 30 Minutes in Water

Feed With Synthetic Binder

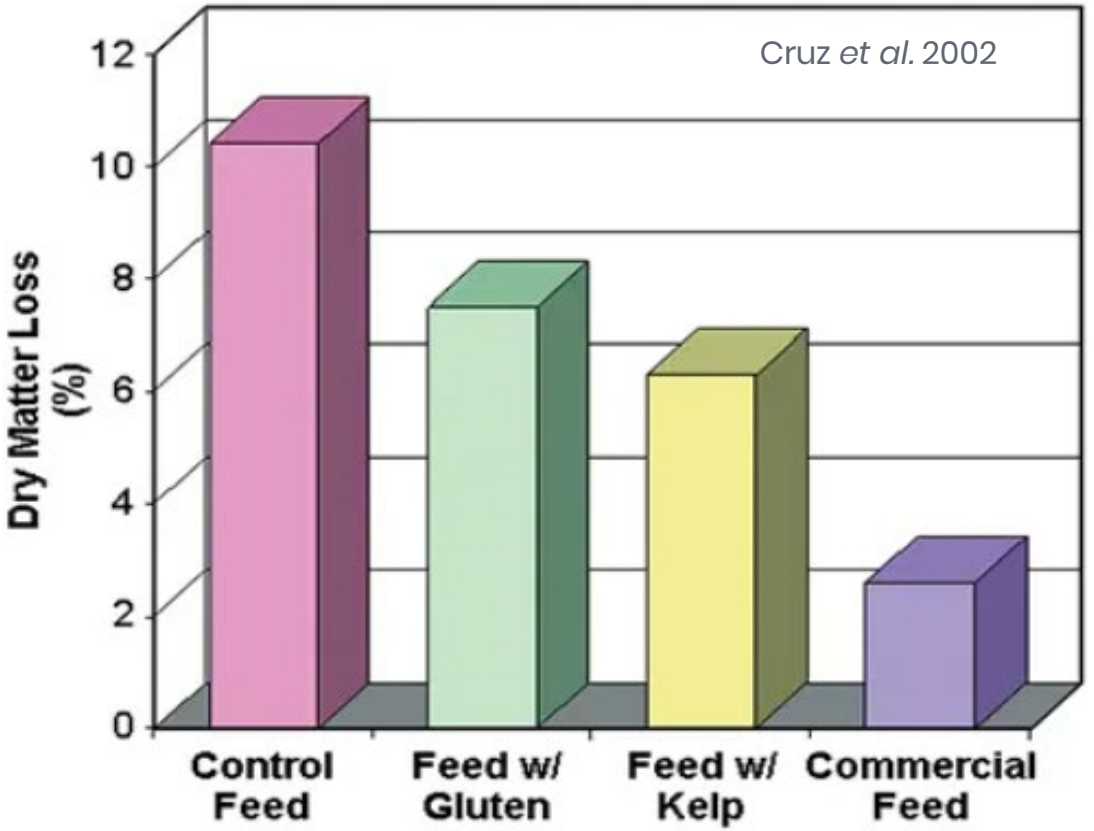
After 30 Minutes in Water

Feeds with a synthetic binder had the highest water stability, followed by kelp meal (Cruz *et al.*, 2002)

Importance of Water Stability for Aquaculture Production

- Reduces wastage and pollution in the aquatic environment
- Allows sufficient time for shrimp to locate and consume the feed
- Maximization of feed utilization and reduction of nutrient-loss

Leaching of dry matter after immersion of experimental shrimp feed pellets in seawater

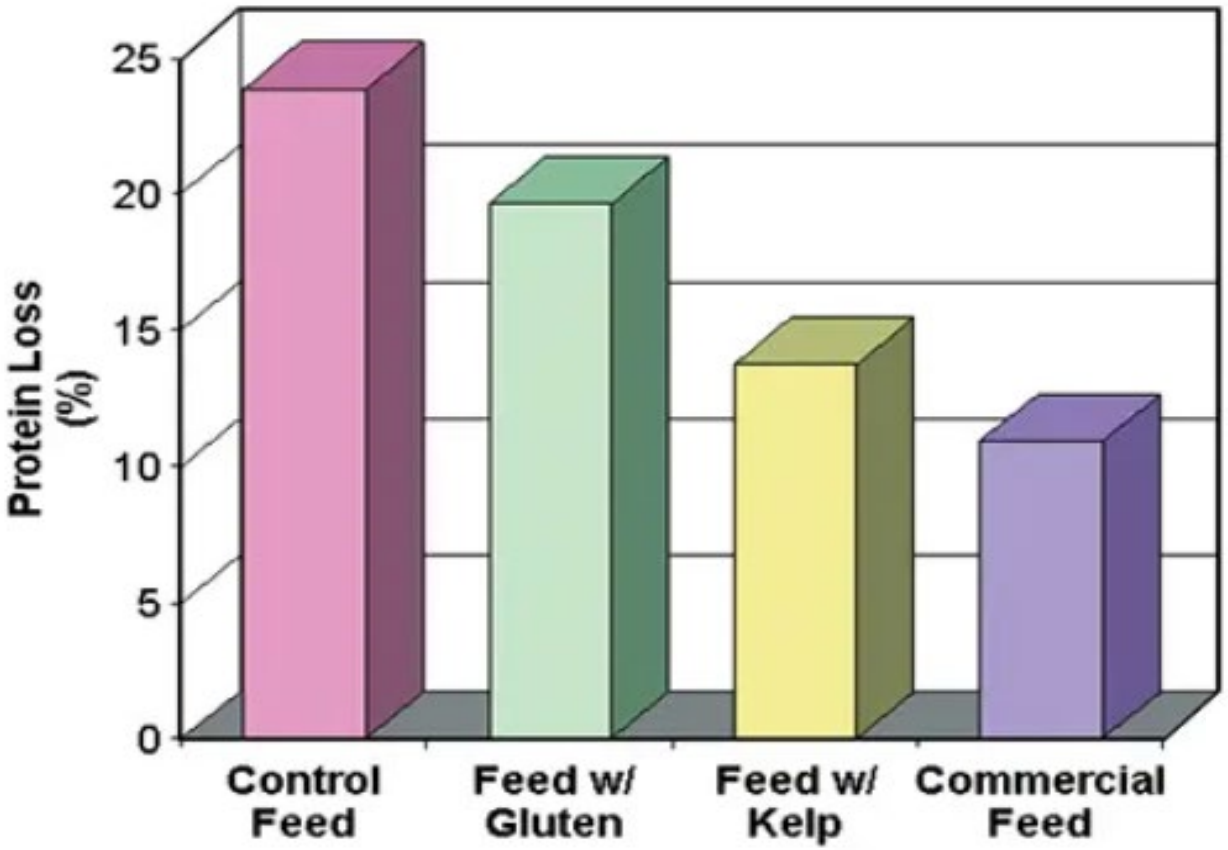


Challenges of Maintaining Feed Integrity in Aquatic Environments

- Feed management
- Water stability and dissolution of the nutrients
- Physical abrasion
- Feed wastage

Protein Loss (%) from the shrimp pellets underwater

Cruz *et al.* 2002



Enzymes Used in the Feed Manufacturing (a few examples)

- Enzymatic hydrolysis: biological breakdown under enzymatic influence:
  - Protease (proteins),
  - Xylanase (NSP),
  - Phytase (phosphorous),
  - Exo/Endo-1,3 β-glucanases (unicellular organisms – a cell wall)

- How enzymes break down complex molecules
  - Protease + Xylanase cleaves protein peptide bonds and releases phosphate (Bae *et al.*, 2013)
  - Cleaves xylan into xylose (Hardt *et al.*, 2014),
  - β-glucanases break down β-glucans attached to the cell wall and produce shorter oligosaccharides (Miladinovic *et al.*, 2022; Jin *et al.*, 2023)

Enzymes need enough free water to react to the substrate! What if you have a critically low aW?

Benefits of Enzymatic Hydrolysis in Shrimp Feed

- Improved digestibility
  - Increasing nutrient availability (Fabrini *et al.*, 2022; Hlordzi *et al.*, 2022)
- Enhanced binding properties
  - Lower viscosity in the upstream processes (Miladinovic *et al.*, 2015)
  - Better physical properties of the final product (Miladinovic *et al.*, 2021)
- Reduced leaching of nutrients (Hlordzi *et al.*, 2022)
- Decreased water solubility (Miladinovic *et al.*, 2021; 2024)

Source: Skretting

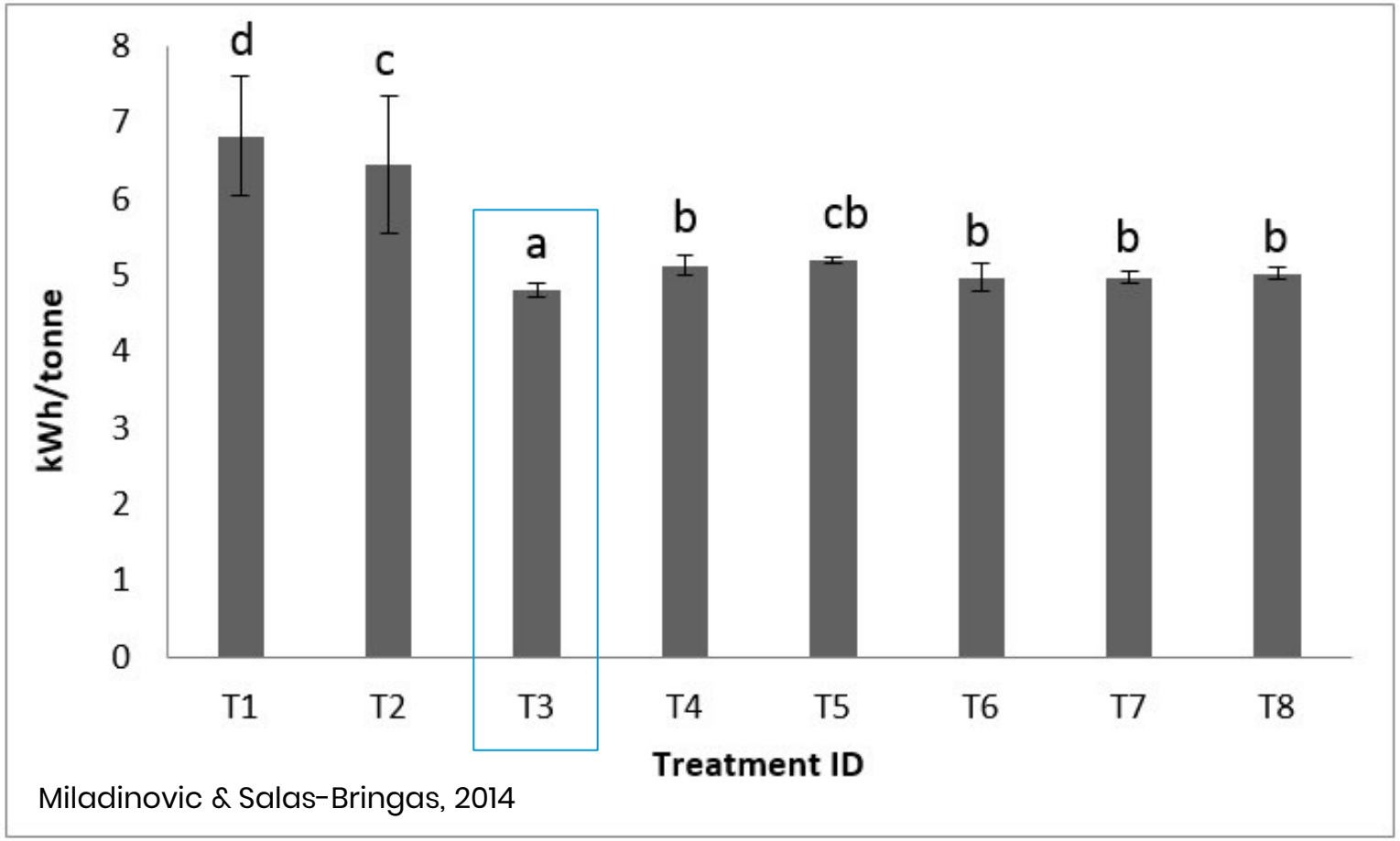
Enhanced Binding Properties (example: protease + phytase)

- Modification of molecular structure:
  - Protease catalyzes hydrolysis reactions (H_20 cleaves the peptide bonds and proteases breakdown complex protein molecules into smaller peptides)
  - Phytase (releasing inorganic phosphate and inositol)

- Improved adhesion between smaller feed particles,

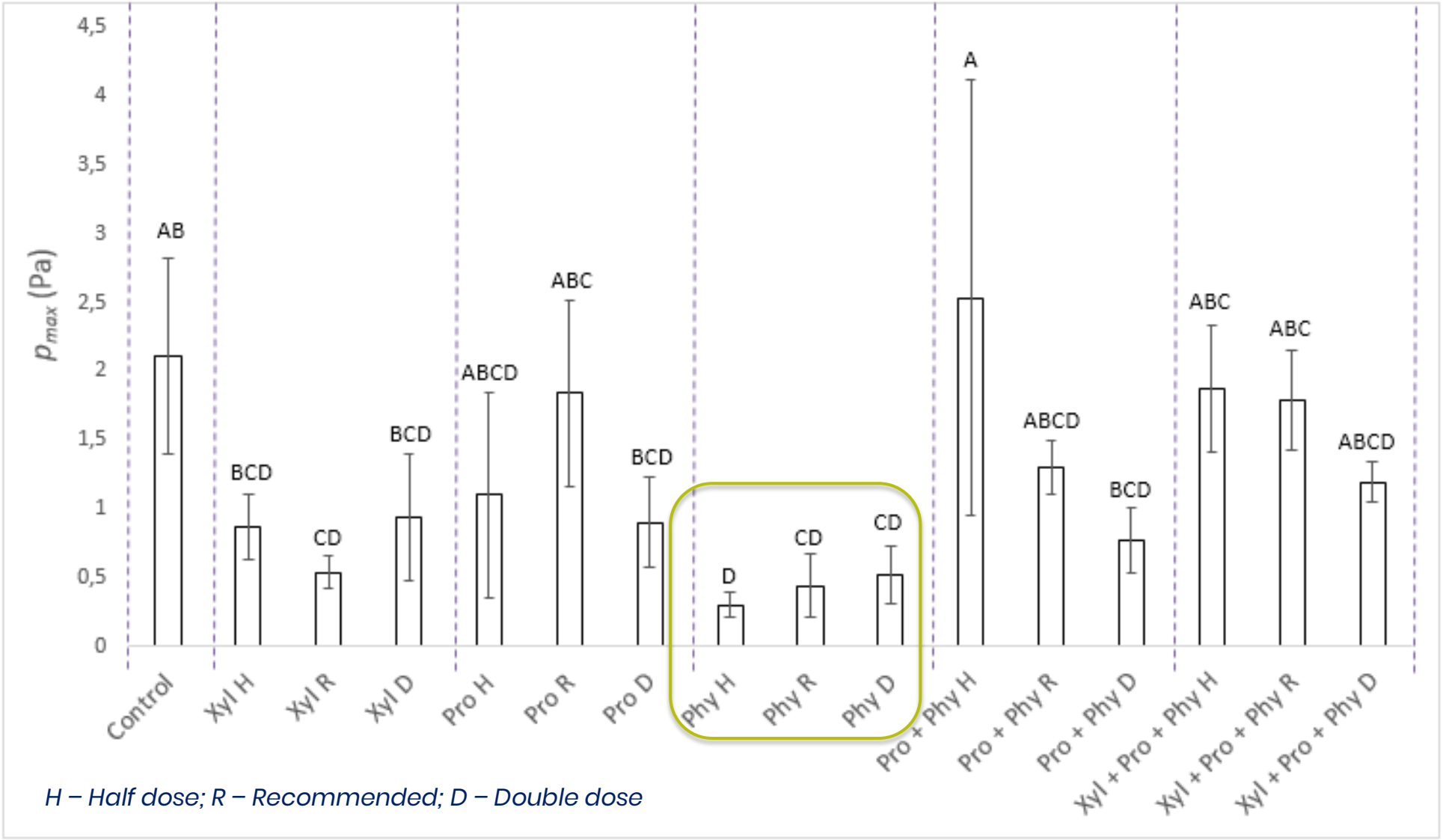
- Maintenance of pellet integrity in water.

Xylanase can Reduce 28% Power Consumption During Pelleting of High Fibrous Materials



Miladinovic & Salas-Bringas, 2014

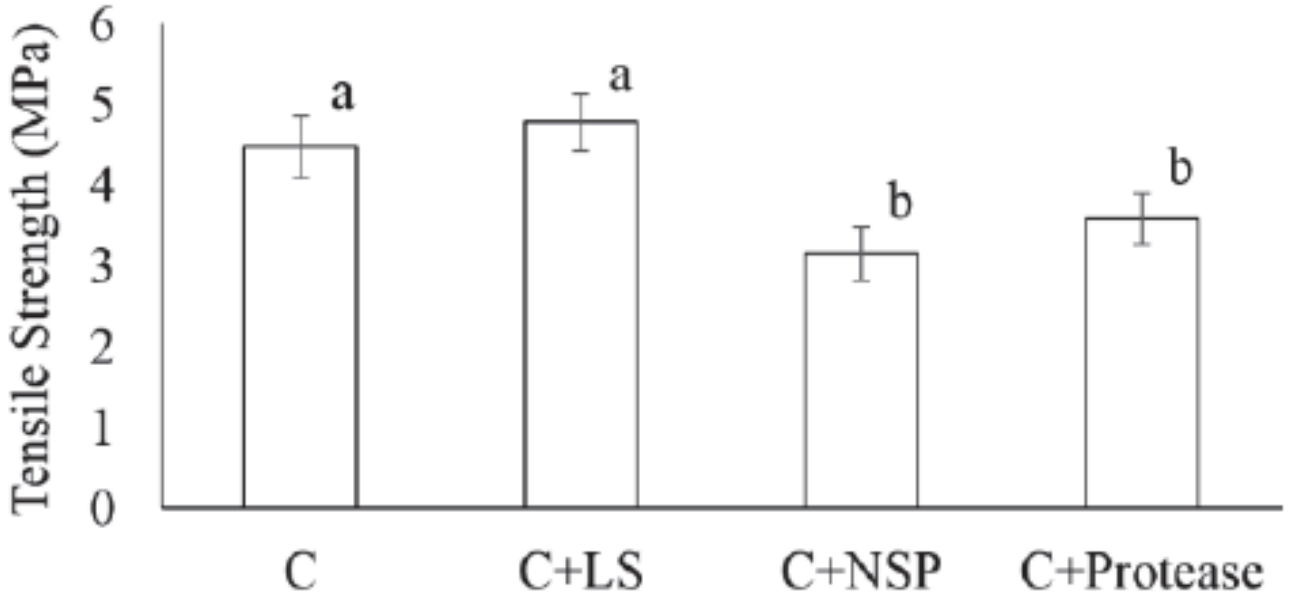
Effect of Phytase and its Dosage on Flow Resistance of Pellets (p-max) in the Die During Microalgal Pellet Discharge



H – Half dose; R – Recommended; D – Double dose

Miladinovic *et al.* 2021

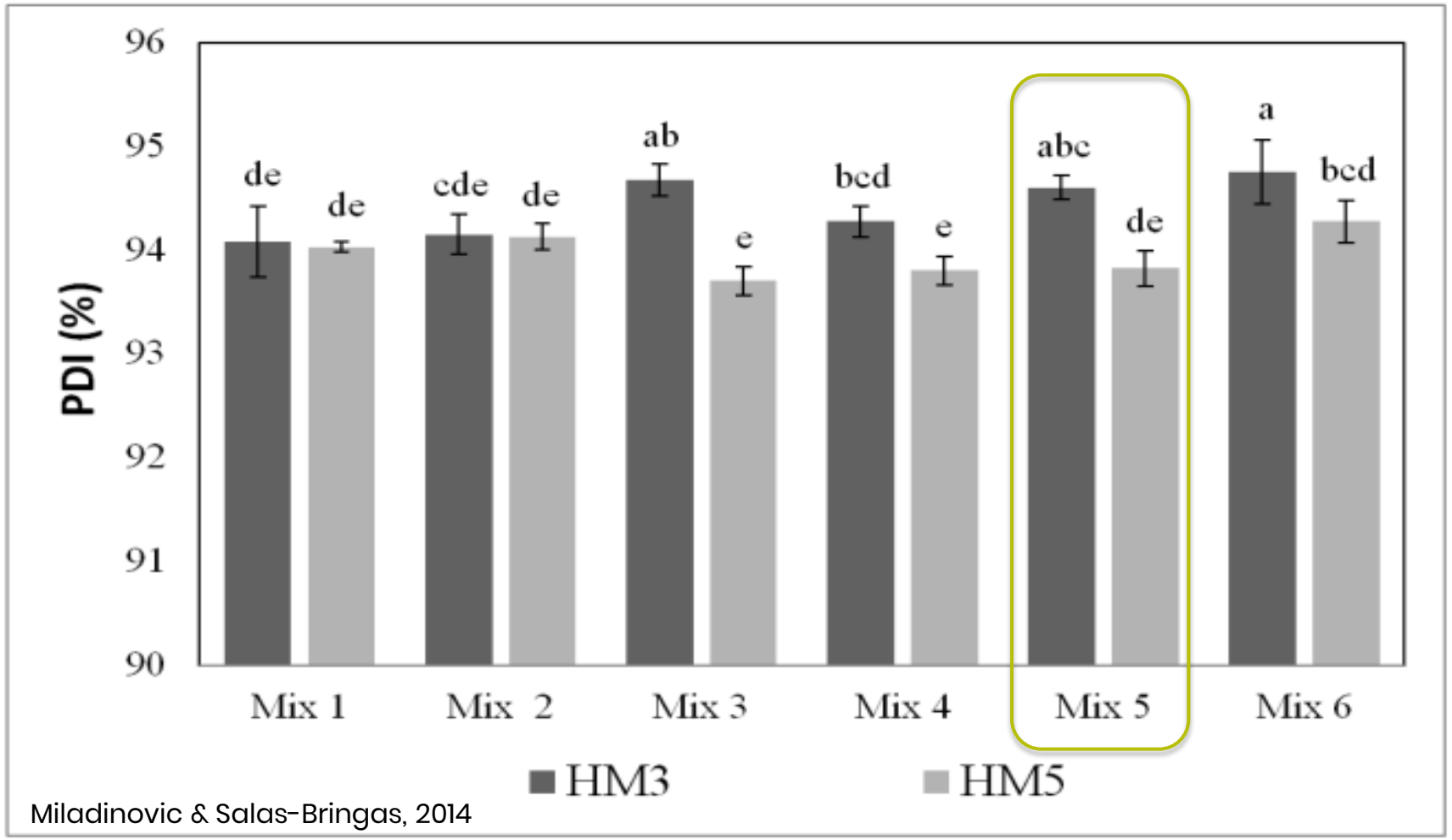
Enzyme Addition Decreased the Tensile Strength of the Microalgal Pellets



C – control; LS – lignosulphonate; NSP – xylanase

Miladinovic *et al.* 2015

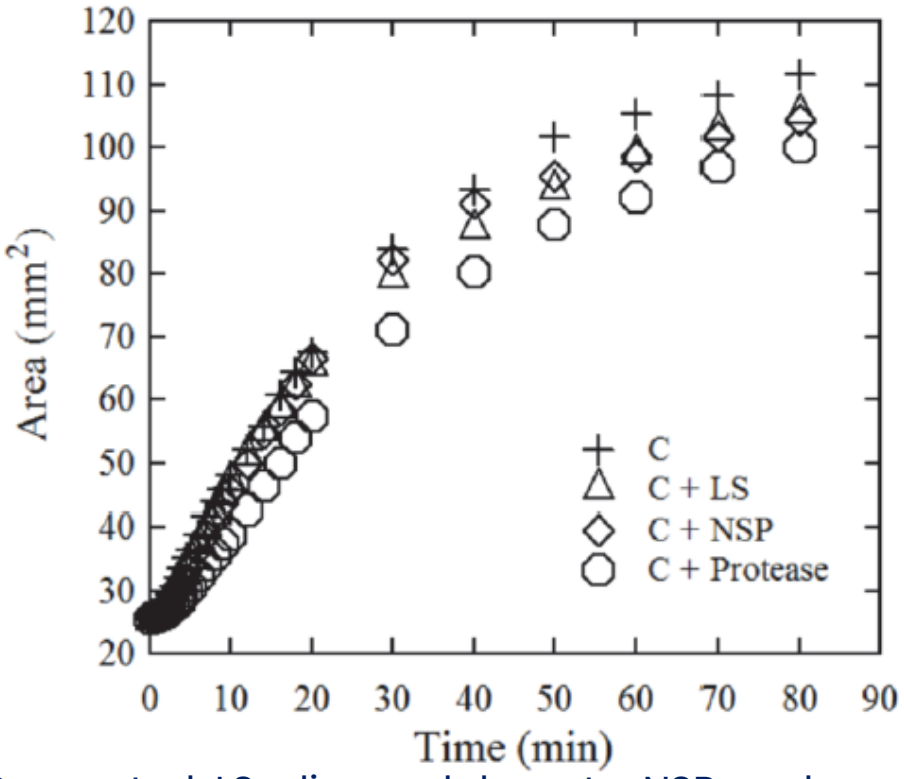
However, LS (0.5%) as a Binder can Repair the Physical Property of the Pellet (Xylanase + LS)



Miladinovic & Salas-Bringas, 2014

Protease Contributed to Reduced Microalgal Pellet Swelling

Average cross-sectional area of pellets placed underwater



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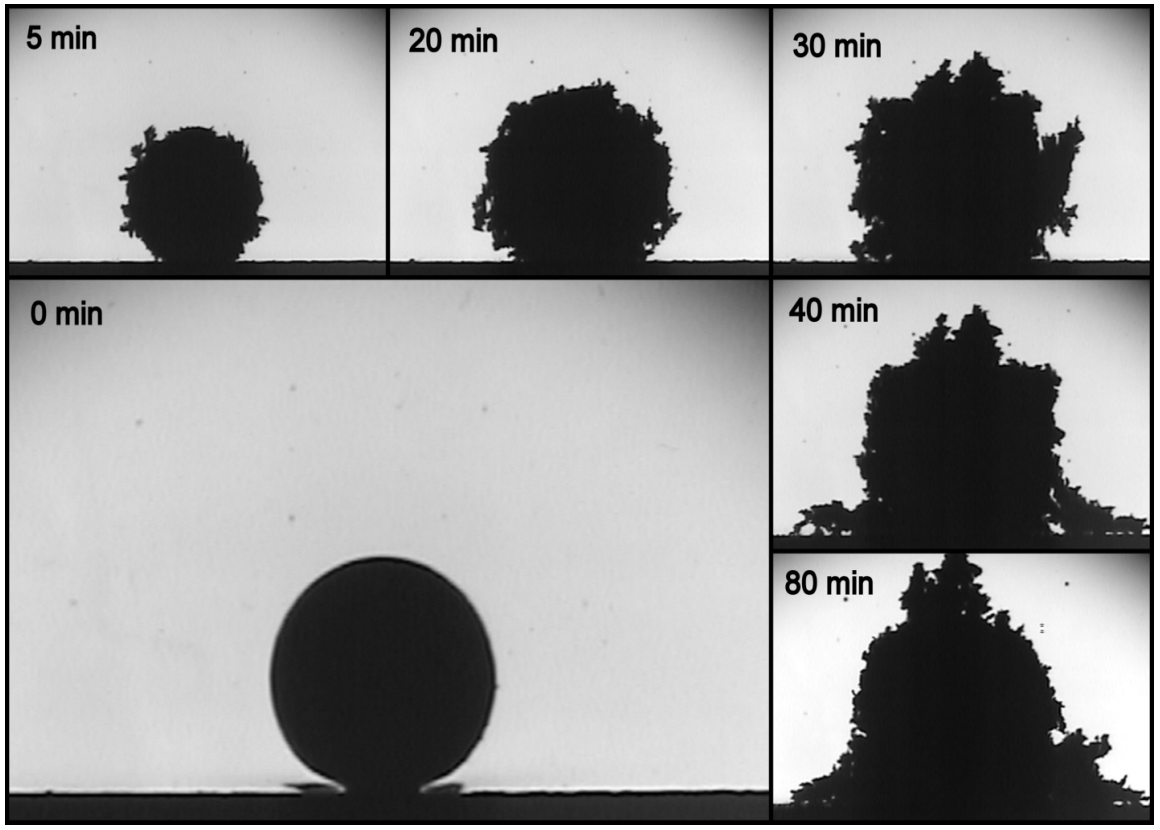
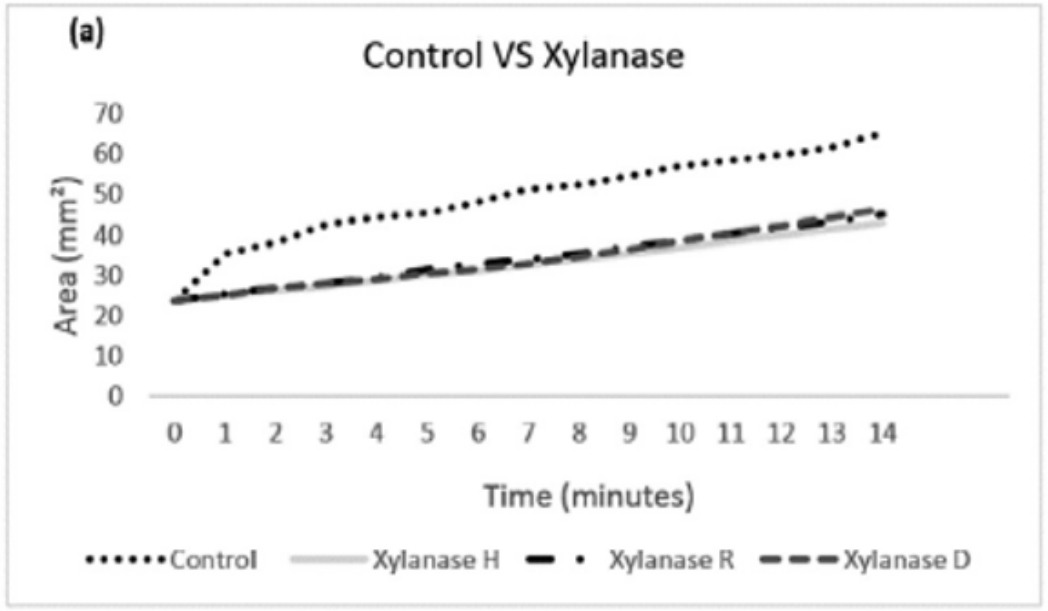
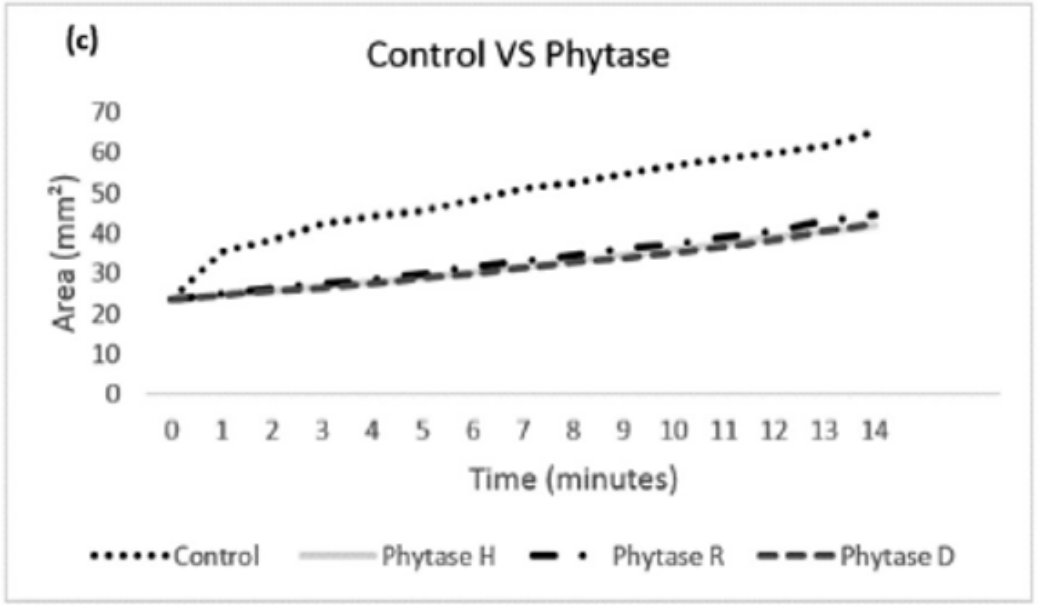


Miladinovic *et al.* 2015

Protease extends the usage time of the pellets underwater, thus allowing the farmed shrimps to find the pellet and consume it!

Underwater Pellet Swelling Decreased by Adding Xylanase or Phytase

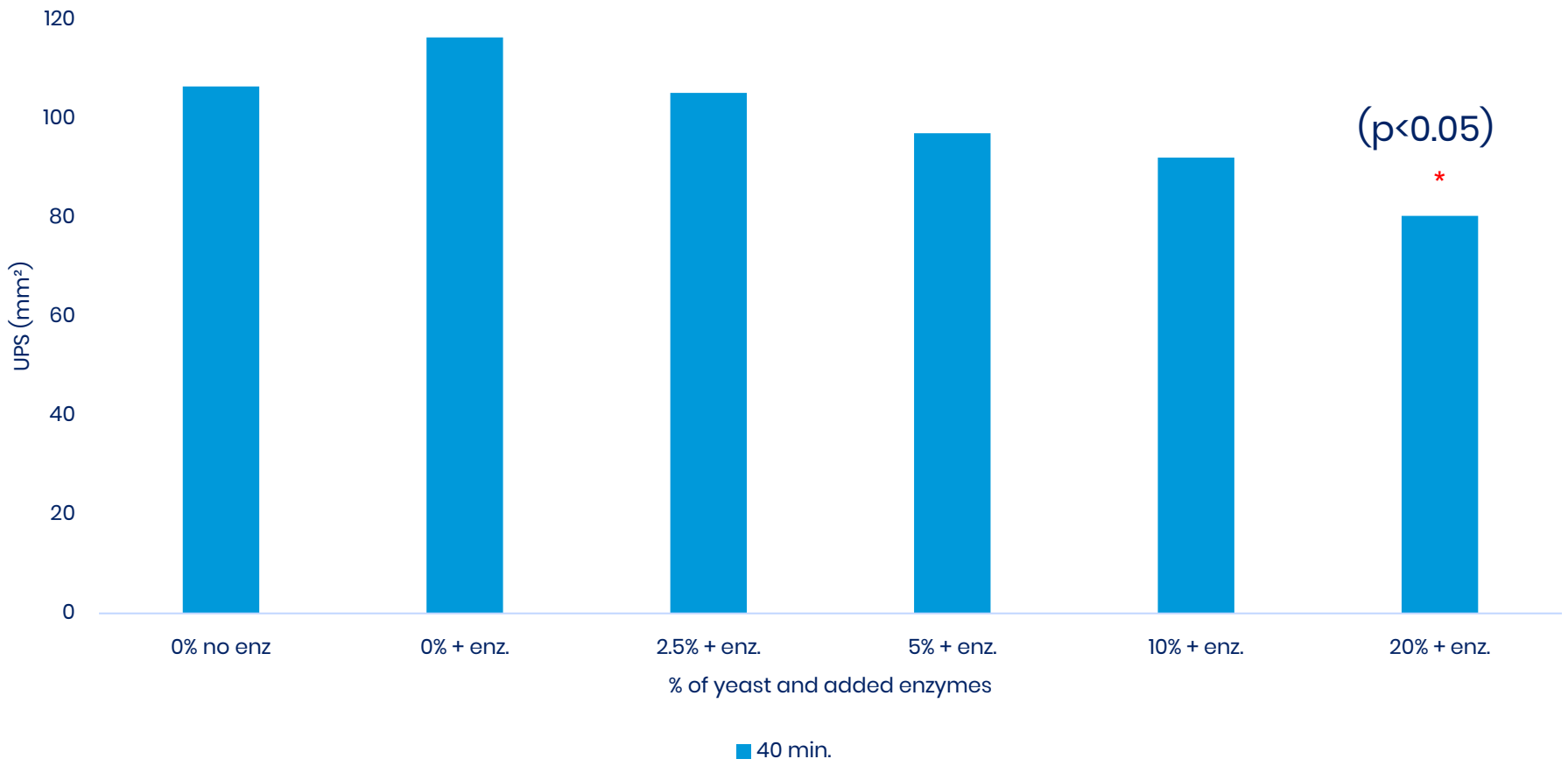




H – Half dose; R – Recommended; D – Double dose

Miladinovic *et al.* 2021

Correct Formulation and Enzymes can Reduce Underwater Pellet Swelling



Miladinovic *et al.*, n.d.

Conclusion: Enzymes can Decrease Water Solubility of the Shrimp Feed Pellets

- Mechanism of reducing feed pellets water solubility through enzymatic hydrolysis;
- Importance for maintaining pellet structure;
- Extended longevity of feed pellets in water.

Conclusion: Good Pellet Integrity Underwater can Reduce Leaching of Nutrients (eutrophication)

Prevention of nutrient runoff (retention of valuable nutrients within feed pellets)

Positive impact on water quality and the aquatic environment

Conclusion: Enzymes as a Tool for Better Physical Pellet Quality can Help Environmental Impact of the Shrimp Feed

- Role of water-stable feed in minimizing environmental impact;
- Reduction of pollution and sedimentation;
- Contribution to sustainable aquaculture practices.

Success Stories

- Example of aquaculture operations implementing enzymatic hydrolysis in shrimp feed production (South America)

- Positive outcomes in terms of feed performance and environmental sustainability

> "Incorporating **enzymatically treated shrimp feed** into our commercial operations has yielded remarkable results. Not only have we observed **significant** improvements in shrimp **growth** rates and overall health, but also notable **reductions in feed waste** and environmental impact."

Overall Conclusion

- Benefits of enzymatic hydrolysis:
  - Enhanced water stability of the feed pellets,
  - Improved nutrient retention,
  - Preserving ecosystems for future generations,

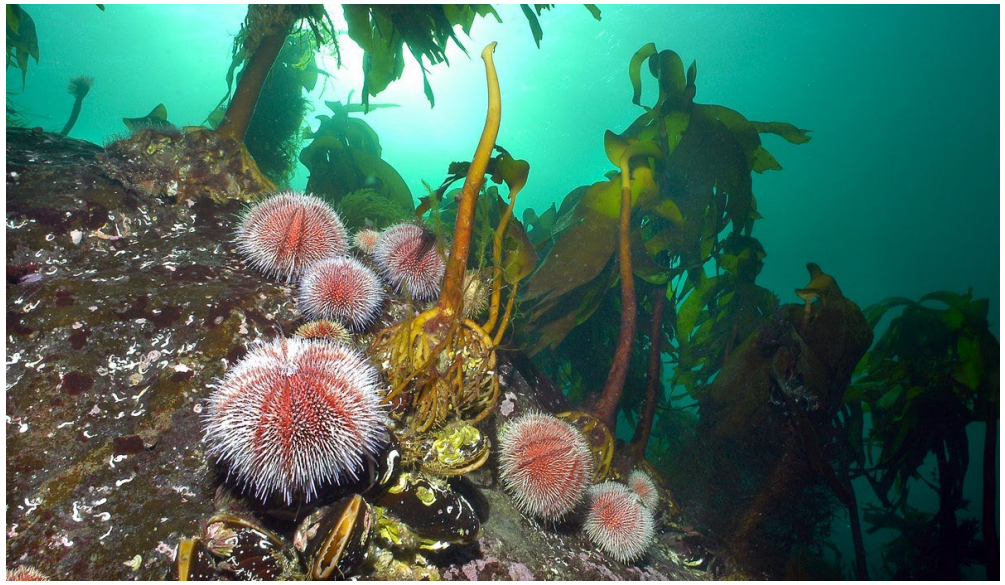
- Transform shrimp farming with enzymatic hydrolysis;

- Enhance efficiency, boost shrimp health, and lead the way to sustainable aquaculture.

Future Directions and Opportunities

- Potential for further research and innovation in enzymatic hydrolysis technologies,

- Expansion of water-stable feed solutions for other aquatic species (sea urchins, abalones, etc..)



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Thank you!

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