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The effect of live and dead spent brewer's yeast (*Saccharomyces cerevisiae*) on the physical characteristics and water activity/moisture relationship of fish feed when utilized as a protein replacement

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Introduction and Objectives

Spent brewer's yeast (SBY) is a promising alternative protein source to fishmeal in aquafeeds[1]. Large masses of SBY are produced per year and given away for free to livestock farms or dumped[2,3]. In the current system, breweries almost never make money from SBY and/or incur all disposal costs. When yeast is illegally dumped, waterways may be negatively affected by the high total suspended solids and biological oxygen demand of yeast.

Additionally, sustainability of current aquaculture feeding systems needs improvement and could be assisted by SBY[4]. Fish populations that are used to produce fishmeal for aquaculture feeds are under threat by the current system, due to a variety of factors. Most importantly, these fish species experience habitat and population degradation from overfishing[4].

There are many documented benefits of SBY on fish growth and feed efficiency[5,6,7]. These benefits are especially apparent regarding live yeast, which has been shown to improve fish immune health and a variety of growth characteristics[5]. Dead yeast does not impart as many immune benefits but can be used as a protein replacement[5]. Yeast does not have a complete amino acid profile, and is notably deficient in sulfur amino acids, but contains high levels of some important amino acids that are required for fish growth[6]. The complete amino acid profile of dried yeast is detailed in Table 1.

Despite a vast amount of research regarding the effects of yeast on fish, there is scant literature on effects of yeast on feed physical characteristics, presenting an opportunity for novel research.

Aquaculture may be a viable destination for SBY for commercial breweries, especially in states that are advanced in both industries, such as Florida. Even if SBY cannot be sold profitably to aquaculture farms, it can be valuable as an alternative destination for waste disposal.

The specific objectives of this study were to produce extruded aquafeeds with 20% of protein usually provided by fishmeal replaced with protein from SBY, and to assess the moisture sorption isotherms, textural characteristics, and water stability of the feeds. These characteristics were assessed by producing six feeds: a yeast-free control feed and feeds with live and dead yeast at high and low moisture contents.

Table 1. Amino acid content of dried brewing yeast (mg/100 g)

	Total amino acid	Free amino acid
Methionine	688.0	60.6
Cystine + cysteine	461.2	31.8
Lysine	4541.2	307.3
Threonine	2119.4	118.5
Arginine	2740.8	561.7
Isoleucine	1396.6	177.0
Leucine	2888.7	281.9
Valine	1823.6	262.3
Histidine	1297.0	241.7
Phenylalanine	1626.9	189.8
Glycine	1973.4	169.4
Serine	2757.0	243.3
Alanine	3699.4	1289.1
Aspartic acid	4150.0	259.3
Glutamic acid	5457.4	1835.8

Methods

- Yeast sourced from First Magnitude Brewing Co. (Gainesville, FL)
- Extruded aquafeeds produced with dead and live ale yeast at 15% MCwb and 5% MCwb, plus a yeast-free control based on commercial sturgeon feeds. Protein replacement was 20% of that usually provided by fishmeal; total protein was ~40% for each feed.
- Moisture isotherm:
  - Water activity and moisture content
  - Three-parameter GAB model
- Texture:
  - Compression test (n=30)
  - Max force and impulse
  - One-way ANOVA followed by Tukey's HSD at α=0.05
- Water stability
  - Feeds submerged in wire baskets and shaken for set times
  - Curve generated using 4P logistic model
  - Extra sum-of-squares F-test at α=0.05

Figure 4. Diagram of extruder used to produce experimental aquafeeds

Results and Discussion

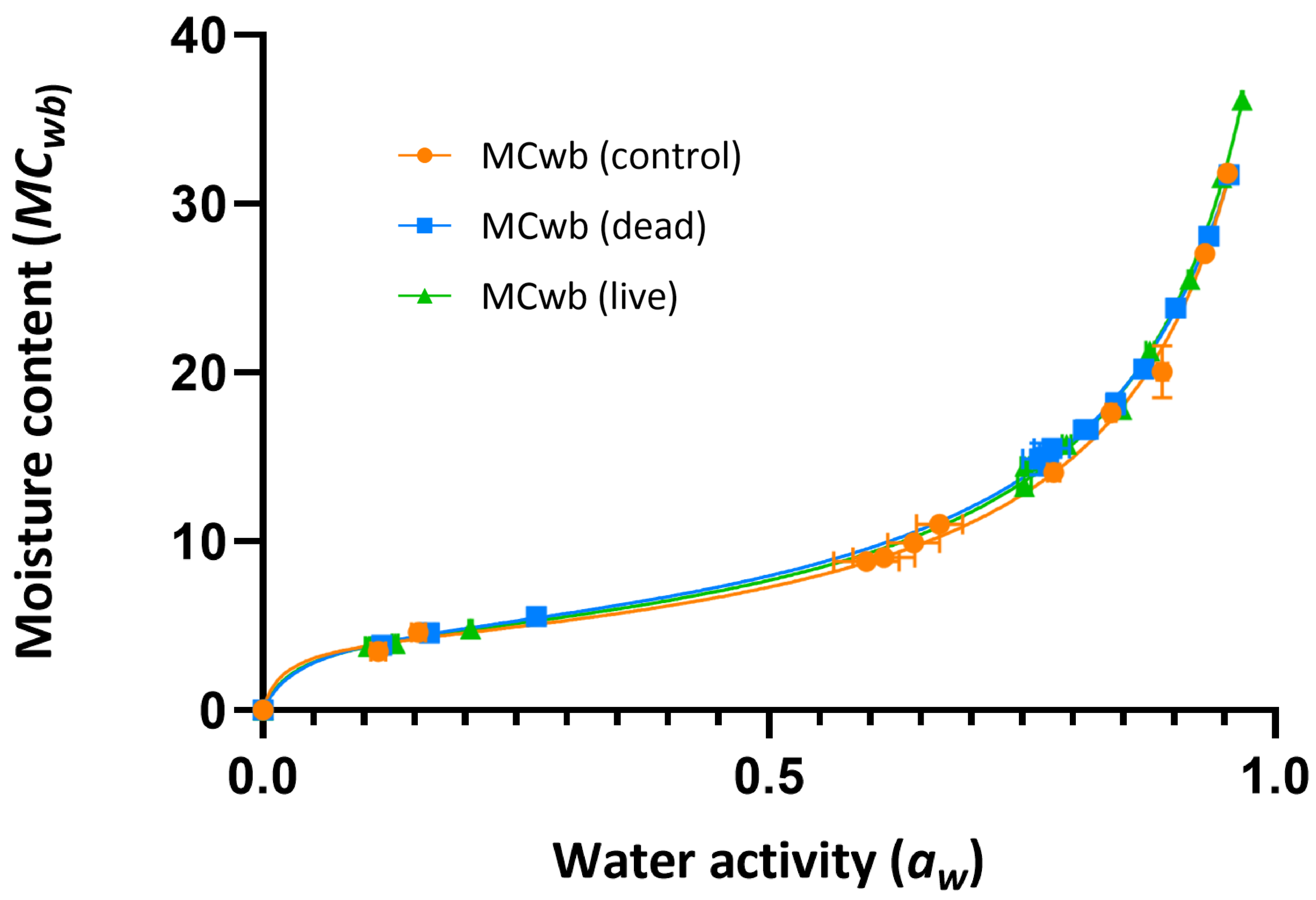

Figure 1. Moisture sorption isotherm of control and yeast-inclusive feeds.

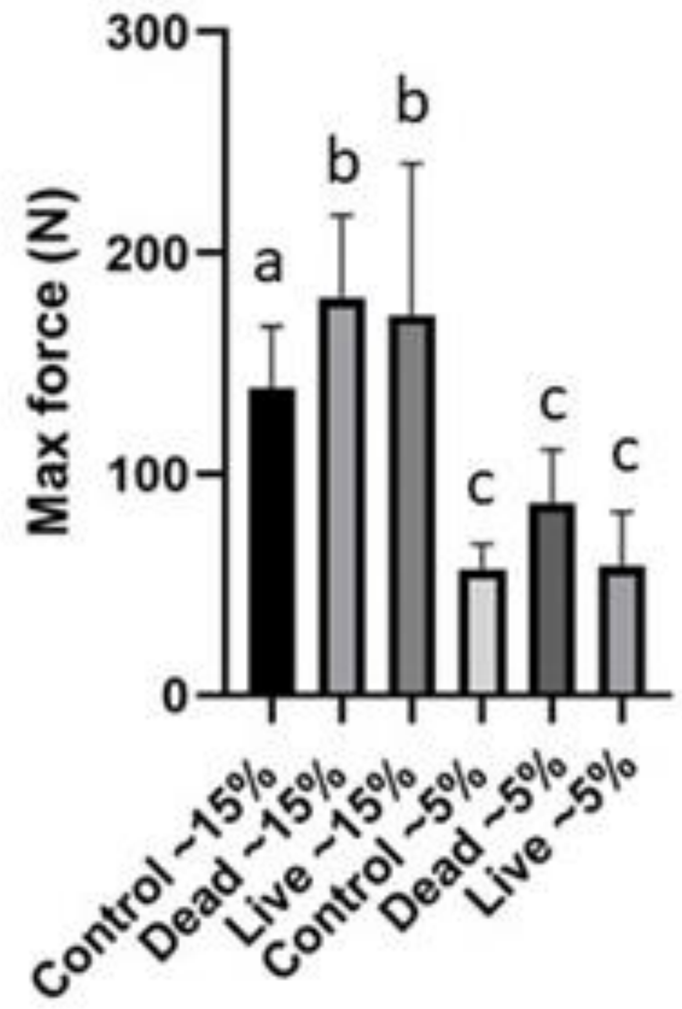

Figure 3. Maximum force of live, dead and control aquafeeds at 15% and 5% MCwb

All yeast-inclusive feeds followed similar isothermal trends as the control (Figure 1). This result indicates that inclusion of yeast in feed formulations does not affect the drying relationship with moisture content. The monolayer a_w for all feeds was ~4% MCwb (a_w=0.25). These results are independent of initial moisture content. While dead yeast-inclusive feeds could be extruded at the same initial moisture content as yeast-free formulations (31% MCwb), live yeast started at higher MCwb (36% MCwb) to be successfully extruded. Drying time to reach final moisture contents varied slightly across feeds, with the control feed taking about 2 hr to reach 15% MCwb and the yeast-inclusive feeds taking about 2.5-3 hr to reach the same moisture content. Just as in extrusion, these differences between control and yeast-inclusive feeds do not necessitate significant procedural modifications in the preparation of yeast-modified feeds.

At high moisture content, the max force of dead and live yeast-inclusive feeds were significantly greater than the control feed (Figure 2). At low moisture content, no significant differences were observed between feeds, as the pellets became brittle and completely broke apart when impacted by the probe (Figure 2). Max force values at high moisture aligned with values found in literature. It is important to note that higher max force values are not necessarily preferred for aquafeed formulations, and preferability largely depends on intended species and application.

The water stability of the dead yeast feed was significantly lower than the control, and significantly greater than the live yeast feed. However, in the literature, water stability analysis is usually performed for about one hour. The water stabilities for all three feeds were in line with values found in the literature[8].

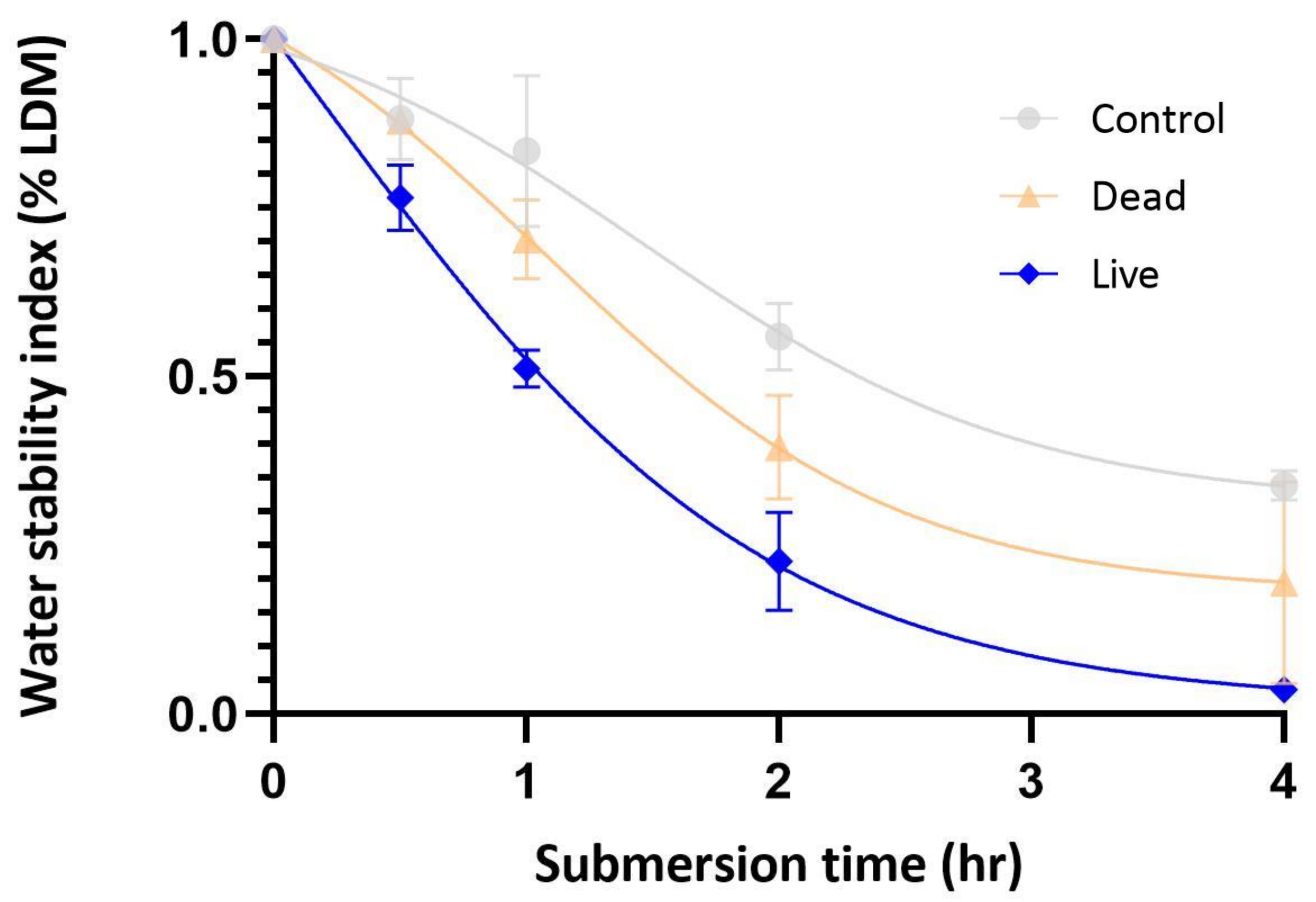

Figure 2. Water stability of feeds at 15% MCwb, by % loss of dry matter

Conclusions

- Yeast inclusion had no effects on the relationship between moisture content and water activity.
- Yeast inclusion resulted in significant increases in hardness at high moisture, but not low moisture.
- Water stability significantly decreased with yeast inclusion.
- Aquaculture can be a new destination for yeast for commercial SBY from a textural and physical standpoint.

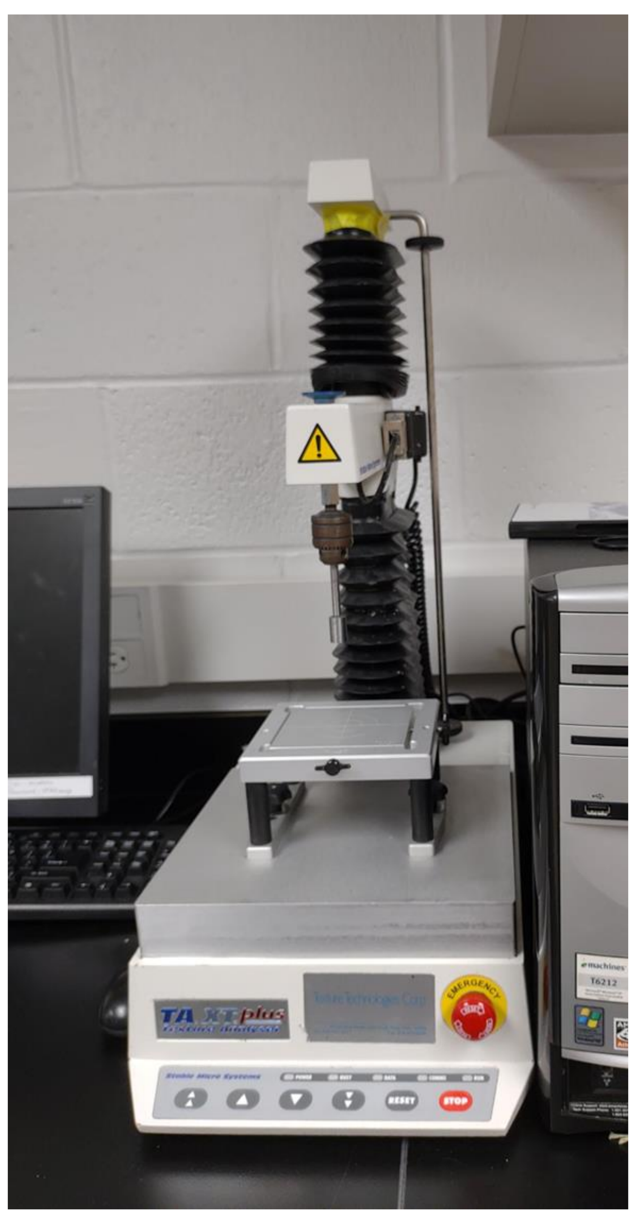

Figure 5. Texture analyzer used for textural analysis

Considerations for Future Work

- Feed trials are a necessary step for determining the efficacy or SBY in aquafeeds to assess fish health and growth, palatability.
- Follow-up research to this study has assessed the biomass production of various brewing yeast strains and their physical effects on aquafeeds.
- Economic analysis must be performed to assess the cost-effectiveness of using SBY for aquaculture farms. The price of fishmeal continues to rise, and if SBY is definitively cheaper than fishmeal, aquaculture facilities may be more willing to adopt it as an alternative protein source.

Acknowledgements

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