**Universidade de São Paulo
Escola Superior de Agricultura “Luiz de Queiroz”**

Leveduras de processos de bioetanol: potencial para a produção de cerveja especial com mosto de alta densidade

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Tese apresentada para obtenção do título de Doutora em
Ciências. Área de concentração: Microbiologia Agrícola

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RESUMO

Leveduras de processos de bioetanol: potencial para a produção de cerveja especial com mosto de alta densidade

A crescente demanda por cervejas especiais tem levado o setor a buscar inovações. No âmbito da fermentação, as leveduras constituem o ponto crucial, tanto no que se refere à tolerância aos estresses do processo quanto no que tange à produção dos compostos aromáticos da bebida. Processos cervejeiros com mosto de alta densidade (*high-gravity* (HG)) impõem condições mais estressantes às leveduras devido à maior pressão osmótica no início da fermentação e maior teor alcoólico ao final da mesma. Leveduras isoladas de processos de bioetanol poderiam ser oportunas à produção de cervejas com mosto HG, podendo contribuir com atributos fisiológicos relevantes e também para a obtenção de um produto diferenciado, com peculiaridades de sabor e aroma. Objetivou-se com este trabalho avaliar o potencial fisiológico e tecnológico dessas leveduras quanto à fermentação cervejeira com mosto HG visando à produção de cerveja especial. Para tanto, inicialmente 24 linhagens de bioetanol e três cepas cervejeiras (controle) foram avaliadas quanto ao crescimento em meio contendo maltose e em mosto cervejeiro HG. Sete cepas foram incapazes de se desenvolver satisfatoriamente, sendo inapropriadas para o processo cervejeiro e, por isso, excluídas da seleção. As linhagens selecionadas foram analisadas quanto a parâmetros fisiológicos em fermentações de mosto HG e a outros atributos relevantes ao processo. Cinco linhagens foram selecionadas para a produção das cervejas. As análises físico-químicas e sensorial mostraram que as cepas de bioetanol agregaram características organolépticas de interesse em cervejas. O ambiente de processos produtivos de bioetanol se mostrou como uma fonte oportuna de biodiversidade, até então não explorada, para os processos cervejeiros, destacando linhagens com potencial fisiológico e tecnológico para a elaboração de cervejas especiais diferenciadas, com peculiaridades de sabor e aroma.

Palavras-chave: *Saccharomyces cerevisiae*; Cerveja; Etanol; Alta densidade; Análise sensorial; Estresses

ABSTRACT

Yeasts from bioethanol process: potential for specialty beer production with high-gravity wort

The increasingly demand for specialty beers has led production sector to search for innovations. In the fermentation scope, yeasts are a crucial point, both because of process stress tolerance as well as beer aromatic compounds production. Brewing process which use high-gravity (HG) worts impose higher stressful conditions to the yeast due to increased osmotic pressure in the beginning, and higher ethanol concentration at the end of fermentation. Yeasts isolated from bioethanol process could be opportune to beer production with HG wort, contributing to both relevant physiological traits and also to obtain differentiated specialty beer, with flavor and aroma particularities. In this work, the physiological and technological potential of bioethanol yeast strains have been evaluated for HG brewery wort fermentation for production of specialty beer. Initially, 24 bioethanol yeast strains and 3 commercial brewing yeasts (controls) were evaluated for growth in maltose medium and in HG brewery wort. Seven bioethanol yeast strains were not able to grow efficiently on maltose and HG wort, and were therefore unsuitable for brewing, being excluded from selection. Selected strains were evaluated for physiological traits in fermentation assessments of HG wort and for other relevant brewing traits. Five strains were selected for beer production. The physicochemical and sensorial analyses demonstrated that the bioethanol strains contributed to desirable organoleptic traits to the beers. The bioethanol process environment presented a valuable source of biodiversity, so far unexploited, to brewing process, highlighting strains with physiological and technological potential to produce differentiated specialty beers, with flavor and aroma particularities.

Keywords: *Saccharomyces cerevisiae*; Beer; Ethanol; High-gravity; Sensorial analysis; Stress

INTRODUÇÃO

Dentro do segmento de bebidas alcoólicas no Brasil, as cervejas representam o maior mercado, correspondendo, em 2015, a um volume de produção que ultrapassou 13,8 bilhões de litros (SISTEMA DE CONTROLE DE PRODUÇÃO DE BEBIDAS – SICOBEB, 2016), sustentando o país na terceira posição no ranking mundial dos maiores produtores da bebida (KIRIN BEER UNIVERSITY, 2015).

Neste segmento, as cervejas especiais conquistam cada vez mais espaço, principalmente pela qualidade superior, atrelada a características sensoriais diferenciadas, e também pelo aumento contínuo da demanda de brasileiros, que passam a consumir produtos com maior valor agregado (BRASIL, 2013; ASSOCIAÇÃO BRASILEIRA DE BEBIDAS - ABRABEB, 2014).

As cervejas especiais podem ser produzidas a partir de mostos com diferentes densidades originais, ou seja, mostos com diferentes concentrações de açúcares. Nas fermentações tradicionais são utilizados mostos em torno de 12°P, enquanto que nas fermentações de alta densidade (*high-gravity brewing*), se utilizam mostos entre 16 a 18°P (BLIECK et al., 2007). Concentrações mais elevadas de açúcares acentuam algumas condições de estresse para a levedura, como a pressão osmótica no início da fermentação, e o maior teor alcoólico ao final da mesma (GIBSON et al., 2007; LODOLO et al., 2008).

Tais condições influenciam a atividade fisiológica da levedura, bem como seu desempenho fermentativo, refletindo na qualidade da cerveja (PIDDOCKE et al., 2009; LEI et al., 2012; YU et al., 2012), sendo muito importante, então, que a levedura se mantenha metabolicamente ativa, ou seja, com elevada viabilidade. O adequado estado fisiológico da linhagem é determinante para manter as características sensoriais da bebida, e além disso, é de particular interesse que a levedura consiga tolerar fermentações subsequentes (reciclo celular), como é usualmente praticado na indústria cervejeira (PRATT et al., 2003; BLIECK et al., 2007; STEWART; RUSSELL, 2009).

A crescente demanda por cervejas especiais vem impulsionando o setor a buscar inovações para o seu processo. No âmbito da fermentação, as leveduras constituem um ponto chave, tanto no que tange à tolerância aos estresses do processo garantindo sua eficiência quanto no que se refere à produção dos compostos aromáticos da bebida (BOKULICK; BAMFORTH, 2013).

Leveduras provenientes de diferentes fontes se mostram com grande versatilidade fisiológica, podendo ser utilizadas para a elaboração de produtos diversificados (BOKULICH; BAMFORTH, 2013). A variabilidade existente entre linhagens de *Saccharomyces cerevisiae*

isoladas de fontes alternativas pode ser explorada para utilização em outros processos (ALBERTIN et al., 2011). Nessa perspectiva, trabalhos têm destacado linhagens isoladas de frutas (LENTZ et al., 2014), massa base de pão (MARONGIU et al., 2015), ambiente produtivo de cachaça (ARAÚJO, 2013) e processo vinícola (CANONICO et al., 2014), com potencial para o processo cervejeiro, tanto no que se refere a eficiência fermentativa quanto na qualidade sensorial da bebida.

Dentro desse contexto, uma fonte potencial de leveduras ainda não explorada para tal são os processos brasileiros de produção de bioetanol. As linhagens provenientes desse ambiente poderiam ser oportunas à produção de cervejas com mosto de alta densidade, podendo contribuir com atributos fisiológicos relevantes e também para a obtenção de um produto diferenciado, com peculiaridades de sabor e aroma, além de ampliar a gama de leveduras disponíveis para a fermentação cervejeira no Brasil.

CONCLUSÃO

Na biodiversidade encontrada em processos de bioetanol, foi possível destacar linhagens de *S. cerevisiae* com atributos fisiológicos relevantes ao processo cervejeiro.

As cepas selecionadas se mostraram com potencial para a produção de cerveja especial, agregando características organolépticas de interesse em cervejas.

Tais linhagens podem contribuir para a produção de cervejas especiais diferenciadas, com peculiaridades de sabor e aroma.

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