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Valorization of brewers' spent grain (BSG) by submerged edible filamentous fungi cultivation

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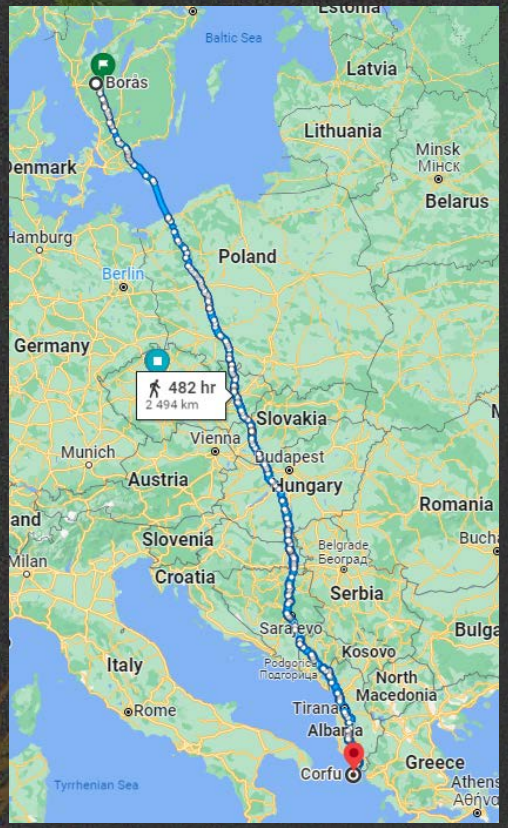
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Austria
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Romania
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Belgrade
Београд
Milan
Croatia
Serbia
Sarajevo
Bulgaria
Kosovo
Italy
Podgorica
Подгорица
North
Macedonia
Tirana
Rome
Albania
Greece
Corfu
Tyrrhenian Sea
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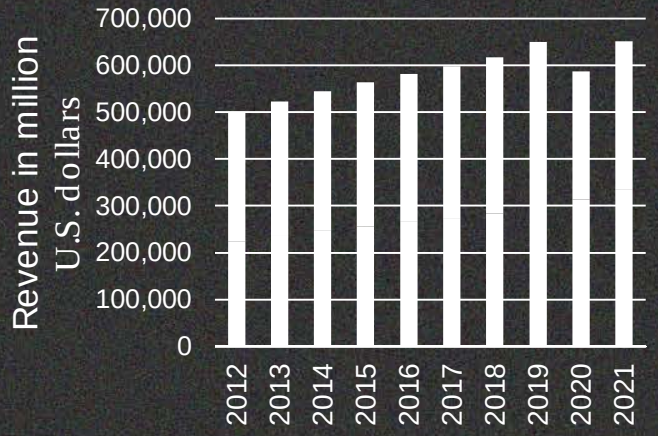
HÖGSKOLAN I BORÅS

Beer

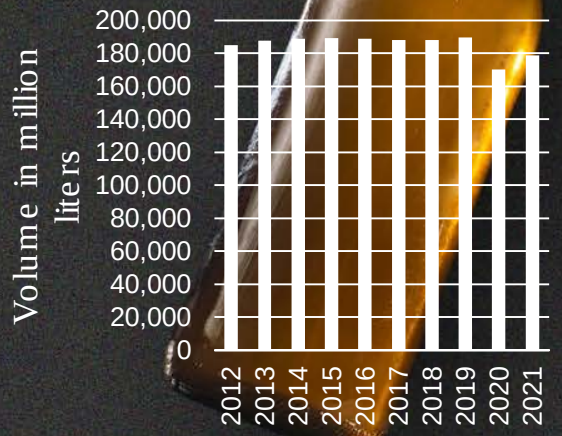
The third most popular drink after water and tea

Revenue of the beer market worldwide from 2012 to 2021



Note: Beer includes fermented beverages made from malt with an alcohol content of more than 0.5% as well as beer mix drinks.
Source(s): Statista Consumer Market Outlook; Statista; ID 1232738

Volume of the beer market worldwide from 2012 to 2021



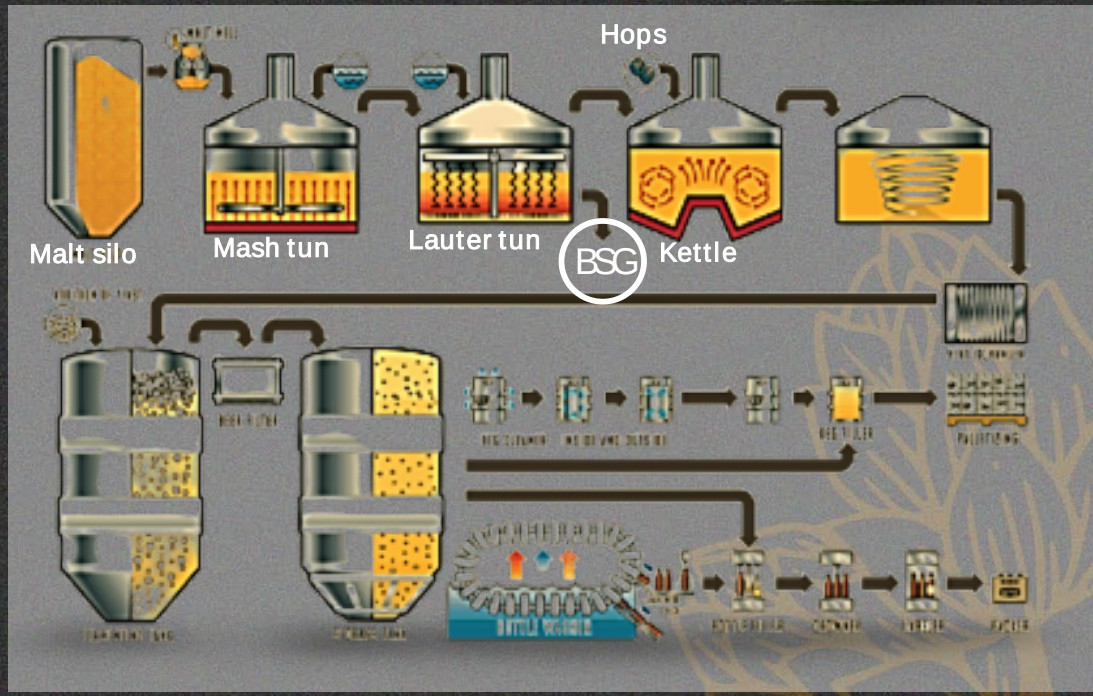
Note: Beer includes fermented beverages made from malt with an alcohol content of more than 0.5% as well as beer mix drinks.
Source(s): Statista Consumer Market Outlook; Statista; ID 1232745

The highest per capita consumption of beer in Europe in 2021

- Czech republic 135 liters
- Austria 100 liters
- Germany 95 liters
- Poland 93 liters
- Romania 87 liters

Brewer`s Spent Grains (BSG)

- It is the main by-product of the brewing industry
- 180 billion liters beer were produced worldwide in 2021
  - around 36 million metric tons BSG produced worldwide.



https://moonshiners.club/wp-content/uploads/2016/08/Beer-production-scheme-2.jpg

Problem

- Low market value
- Limited application as animal feed

Opportunity

- BSG has nutrient rich content
- High-volume low-cost

Component	BSG1	BSG2	BSG3
Cellulose	17.5	17.2	18.9
Hemicellulose	25.5	28.6	29.24
Lignin	15.7	15.4	17.4
Starch	20.9	19.4	19.1
Protein	22.7	18.9	17.9

Components are reported as the percentage of BSG dry weight

✓ Fiber degrade by-product

Submerged Fungal Cultivation on BSG

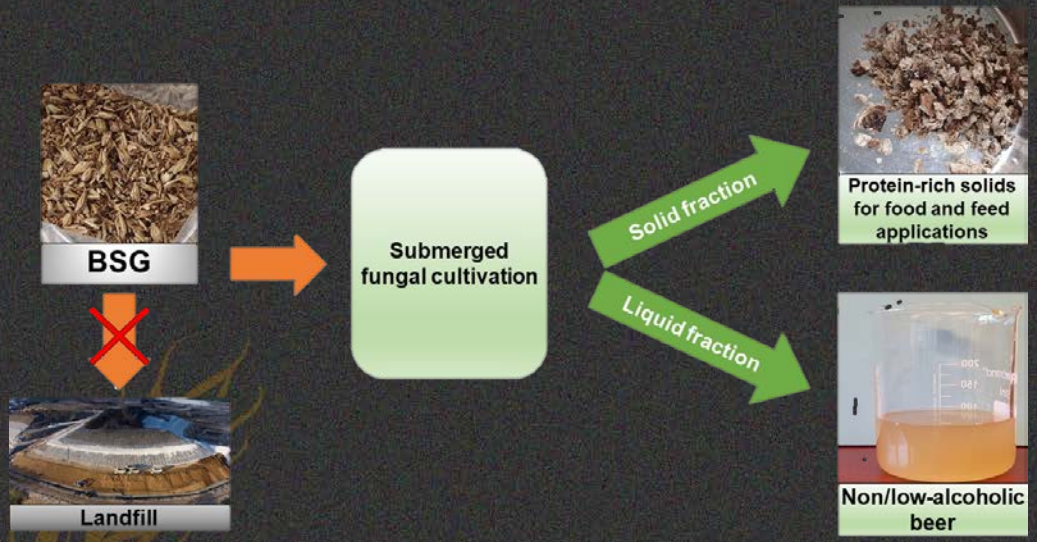
Fungi strains

Neurospora intermedia

Aspergillus oryzae

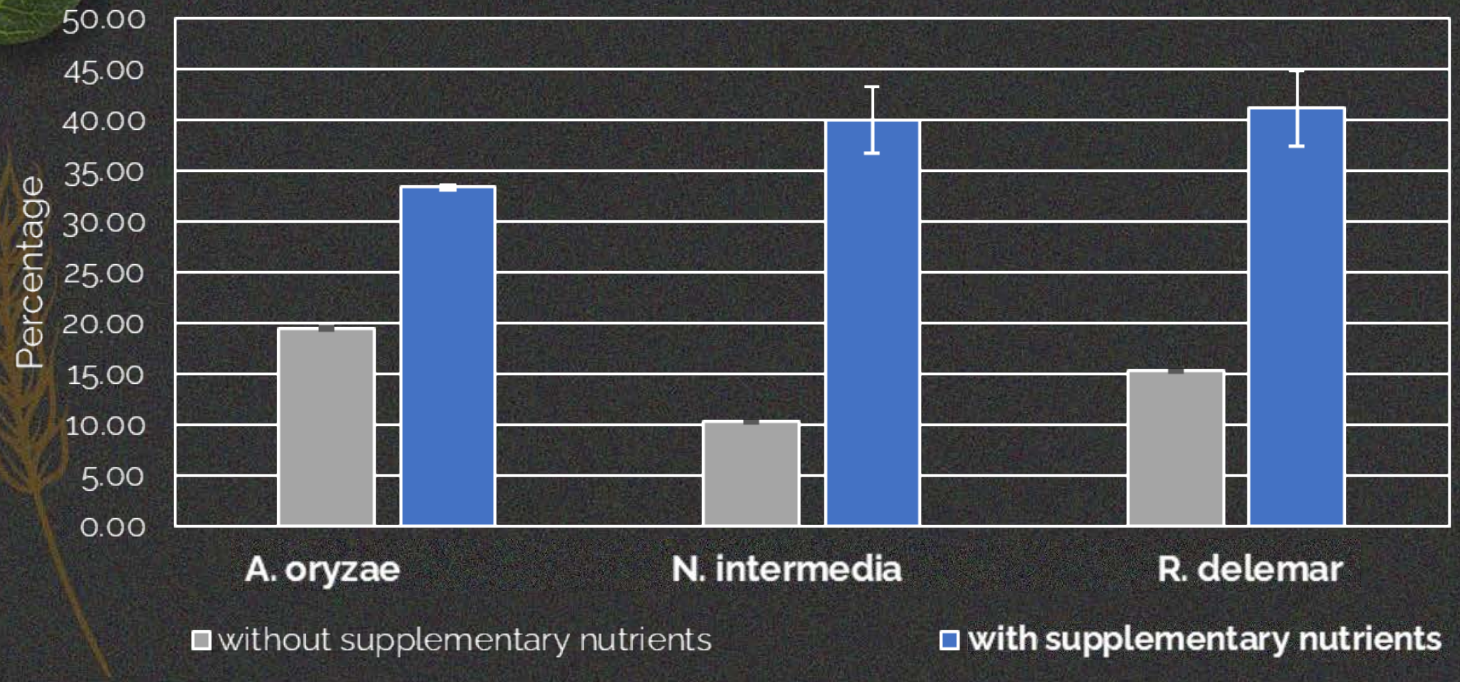
Rhizopus delemar

Submerged Fungal Cultivation on BSG



- **Substrate condition**
  - 30 g/ L BSG without pretreatment
- **Studied Factors**
  - Fungal Strain
  - Medium Supplementation (salts, trace metals, and vitamins)
  - Cellulase Addition

Submerged Fungal Cultivation on BSG



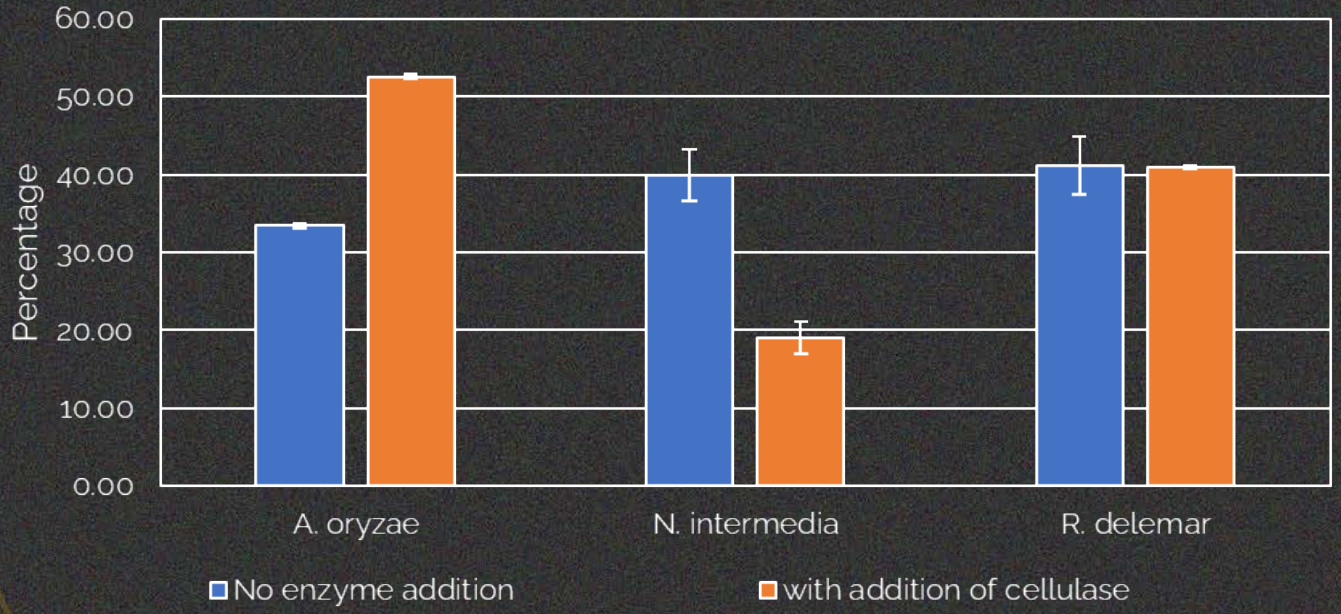
Increase in protein content of biomass after fermentation compared to initial substrate

Submerged Fungal Cultivation on BSG

Concentration of Recovered Solids and Protein Content after fungal cultivation

Cultivation condition	Biomass Parameter	Fungus		
		A. oryzae	*N. intermedia*	*R. delemar*
Without supplementary nutrient addition	Concentration g/L	20.60±0.54	15.62±0.01	20.61±0.16
	protein content %	27.05±0.26	24.99±0.07	26.13±0.12
With supplementary nutrient addition	Concentration g/L	24.89±0.03	24.13±0.46	25.73±1.36
	protein content %	30.22±0.36	31.70±3.39	31.96±3.82

Submerged Fungal Cultivation on BSG



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Submerged Fungal Cultivation on BSG

Concentration of Recovered Solids and Protein Content after fungal cultivation

Cultivation condition	Biomass Parameter	Fungus		
		A. oryzae	*N. intermedia*	*R. delemar*
Without addition of cellulase	Concentration g/L	24.89±0.03	24.13±0.46	25.73±1.36
	protein content %	30.22±0.36	31.70±3.39	31.96±3.82
With addition of cellulase	Concentration g/L	15.77±3.11	16.28±1.00	19.53±0.11
	protein content %	34.57±0.38	26.95±2.15	31.93±0.27

Submerged Fungal Cultivation on BSG

Ethanol yield of fermentation with different fungi at different conditions

	Without addition of cellulase			With addition of cellulase		
	A. oryzae	*N. intermedia*	*R. delemar*	*A. oryzae*	*N. intermedia*	*R. delemar*
Ethanol yield (g/ g substrate)	0.03±0.01	0.05±0.05	0.05±0.01	0.06±0.00	0.09±0.02	0.07±0.02
Ethanol yield (percentage of theoretical yield)	10.14±0.45	16.84±1.54	16.41±0.44	18.03±0.11	29.28±0.76	24.78±0.58

Conclusions

- Submerged fungal cultivation increased BSG's protein content by up to 40% and reduced solid weights up to 47%.
- Higher process output by medium supplementation
- medium supplementation resulted in similar concentration of recovered solids (~24 g/ L) and protein content (~31%) from the cultivation with three investigated fungal strains
- The addition of cellulase cocktail reduced the concentration of recovered solids by 24 to 32%, and it was more favorable for ethanol production.

THANKS

Do you have any questions?

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