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Using Machine Learning with chemical analysis to improve the quality in the brewing process

A study on beer and its brewing process using Machine Learning

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Author (style Abstract Headline)

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Title

Using Machine Learning with chemical analysis to improve the quality in the brewing process – A study on beer and its brewing process using Machine Learning

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Keywords (5–8 words)

chemical analysis, beer quality, sensor, audio classification, image processing, beer brewing, machine learning, computing

Content

1. Problem Definition

This paper will attempt combining machine learning techniques in conjunction with chemical analysis to improve the quality and consistency of the beer brewing process. The study's goal is to create a model that can assess chemical data acquired during the brewing process and forecast the final beer quality, allowing for real-time adjustments to optimise the outcome.

The quality of the beer is dependent on both its recipe ingredients as well as a number of methods of execution. The figure in **appendix A** shows a flow chart of the brewing process from raw ingredients to finished beer.

2. Motivation

Automation is undoubtedly one of the most significant ways in which beer brewing techniques have improved over time. Automation has made parts of the brewing process that used to take a long time more efficient. Brewers can develop more unique beers daily because they have such fine control over the brewing process [1].

Instead of assessing and then tasting the beers manually a Computer Vision system has been used that analyses the external attributes of the beer. The computer vision system takes images and uses them to study the quality of the beers. The parameters include the beer's colour, bubbling, and foam stability [2]. But just analysing each trial of beer brewing is quite ineffective compared to being able to predict the best parameters for the recipe in the first place.

By evaluating data from stages of the brewing process, machine learning can be favourable. This study can aid in the identification of patterns and trends that can be used to improve beer quality and make the brewing process more efficient in the future. In 2018 the pouring process of commercial beers using a robotic pourer, computer vision, and machine learning algorithms were analysed and evaluated. Concluding that this can assist brewers in optimising the pouring procedure and overall beer quality [3]. This made us wonder if it is possible to automate the beer brewing system even more for a better quality beer.

The brewing process can be advanced with deep learning since it has the ability to anticipate the chemical properties of a brewing recipe. This was shown in 2018, a study using deep-learning techniques to predict chemical attributes found that the standard Deep Neural Network, or DNN, did very well, however the LSTM-DNN outperformed on all the tasks [4]. This can help brewers make more informed judgments regarding which ingredients to use and how much to use, as well as how to optimise the brewing process for specific chemical qualities. Deep Learning can also be used to examine vast amounts of historical data from prior brewing batches in order to uncover patterns and trends that can be used to improve the beer's quality and consistency.

3. Research Questions

The following research questions will be addressed in this thesis:

3.1. RESEARCH QUESTION 1: How can image processing be applied in the brewing process to accurately determine the quality of the beer as perceived by beer tasters?

The inclusion of image processing in the brewing process can assist in determining the quality of beer as perceived by beer tasters. This could be accomplished by investigating the ingredients and procedures utilised in the brewing process, as well as their impact on the end product. The most interesting part for us as of now is to investigate if the final product quality is affected by using commercial or wild yeast strains. Other than that there are many other important brewing parameters that might be equally as important that we have not gone in depth with when discussing with the project group. One example of that would be ageing the beer which allows the flavours to finish developing.

This makes us wonder if it is possible to predict the flavour of the beer from the recipe of the beer using machine learning, bringing us to the next research question.

3.2. RESEARCH QUESTION 2: How to predict the flavours, for instance aromas and taste, with the help of chemical analysis and machine learning?

There are already recipes in place for brewing the different beers at Klackabackens brewery, but for developing the future flavours of Klackabackens brewery it would be interesting to know if machine learning could help them create the ultimate beer recipe based on the characteristics the tasters value the most.

4. Methodology

This part of the plan will tell you about the methods used to find the answers to the research questions.

4.1. Literature review

For literature search **see appendix B.** By reading and comparing different articles, and books it is possible to learn alot about the beer brewing process and how differently it is performed in different regions and times. The area that is focused the most is the chemical analysis and interpretations of how it affected the final product. This together with maybe our own experimentation at Klackabacken could possibly answer research question 1.

4.2. Variables

The dependent variables are aromas and taste. While the independent variables that could be changed in the brewing process are Yeast, Temperature, Accumination, Flocculation, Brix (Sugar).

4.3. Outline

The methodology for this study's practical part answering the second research question can be outlined as follows:

1. Data Collection
    - The first step is to gather the necessary chemical data from the beer brewing process, this is all the data for all of our independent variables. This data will be collected by the Gastronomy and Engineer students using various instruments.
2. Data Pre-processing

- The collected data is pre-processed to remove any irrelevant information, correct any errors or inconsistencies, and ensure that it is in a suitable format for the machine learning model.

3. Model Development
    - Next, the Machine Learning model is developed using a suitable algorithm. To discover the correlations between the variables and the final product, the model is trained on pre-processed data.
4. Model Validation
    - The created model is then verified against a test set of data to determine its accuracy and efficacy in predicting the final beer quality.
5. Real-Time Implementation
    - The final step is to integrate the validated model in real-time throughout the brewing process, allowing for real-time tweaks to optimise the final product.

5. Expected Results

We expect to have an accurate machine learning model that can predict the flavour and characteristics of the beer by using the variables combined with images that will have been taken during the brewing process to then be processed and analysed with a separate machine learning model.

We would like to be able, in the future, to input what we want from a beer and the model would deconstruct this and give us accurate instructions on how to make the beer that we desire.

6. Time Plan

The study starts off with 4 weeks of learning and researching about the topic as well as meeting the supervisor and the whole project group including the gastronomy and engineering students where the practical part of data collection will be planned. The next 5 weeks after that will be for executing that plan and finding the best algorithms for the best models. The next 8 weeks will be for writing and analysing the results gathered from the practical part as well as writing the thesis paper. The final 3 weeks are for the opposition and presentation. For a more detailed time plan for every week see **appendix C**.

7. References

[1] How Beer Brewing Techniques Have Evolved Over Time [Internet]. CRAFTMASTER STAINLESS. [cited 2023 Jan 23]. Available from: https://www.craftmasterstainless.com/blog/2022/5/31/how-beer-brewing-techniques-have-evolved-over-time

[2] Lukinac, J. *et al.* (2019) "Computer Vision method in Beer Quality Evaluation—A Review," *Beverages*, 5(2), p. 38. Available at: https://doi.org/10.3390/beverages5020038

[3] Gonzalez Viejo, C. *et al.* (2018) "Assessment of beer quality based on a robotic pourer, computer vision, and machine learning algorithms using commercial beers," *Journal of Food Science*, 83(5), pp. 1381–1388. Available at: https://doi.org/10.1111/1750-3841.14114

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Appendix A

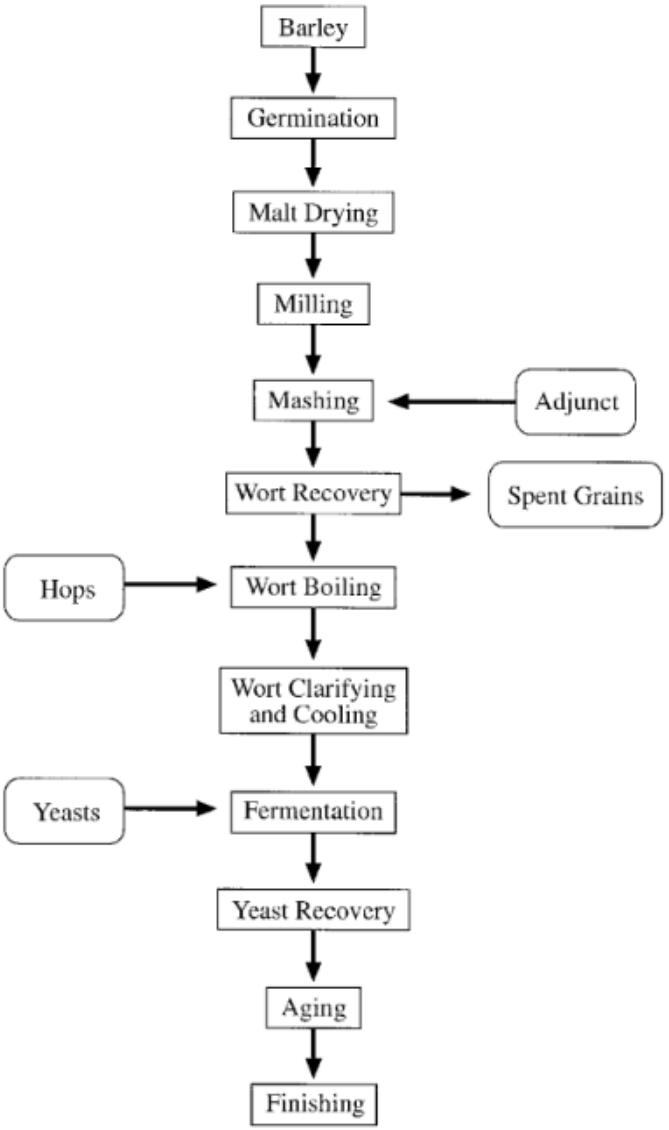

Figure 1. The flow of the whole brewing process[4].

Appendix B

Title	Link	Keywords	Results	DB
Assessment of Beer Quality Based on a Robotic Pourer, Computer Vision, and Machine Learning Algorithms Using Commercial Beers	https://ift.onlinelibrary.wiley.com/doi/abs/10.1111/1750-3841.14114?casa_token=uIxmA6etIzQAAAAA%3A798DUj1cyHPL8ci_3Nkzl7GdINTomntWjwSRpoqa6D7Upqg3_fvGYGMOSb9njyNdmO85uKAvgUYtyBj6	"machine learning" AND "beer brewing"	254	Google Scholar
Deep Learning Approaches to Chemical Property Prediction from Brewing Recipes	https://ieeexplore.ieee.org/abstract/document/8489492?casa_token=GpxwfqzOqf4AAAAA:6LRegS3ZWquLOVeK8oJdpJ2xgwObzXRMRNxhZJUQsggwKAaYOXKjRAjCxGxobfmge0jc9hZ3fk7w7g	"machine learning" AND "beer brewing"	254	Google Scholar
The Importance of a Comparative Characterization of Saccharomyces Cerevisiae and Saccharomyces Pastorianus Strains for Brewing	https://www.mdpi.com/2311-5637/3/3/41		1	Fredrik Frisk
Saccharomyces Cerevisiae Var. Boulardii: Valuable Probiotic Starter for Craft Beer Production	https://www.mdpi.com/2076-3417/9/16/3250	image processing AND beer AND fermentation	45 500	Google Scholar
Computer Vision Method in Beer Quality Evaluation—A Review	https://www.mdpi.com/2306-5710/5/2/38	beer quality AND computing AND image processing AND sensor AND beer brewing	19 500	Google Scholar
Encyclopedia of Microbiology	https://books.google.se/books?hl=sv&lr=&id=fhC_nz8eHh0C&oi=fnd&pg=PA412&dq=beer+brewing&ots=FRY2_YcjWP&sig=tvrbS3qfnqqSBWWs0IFlqlV4QAI&redir_esc=y#v=onepage&q=beer%20brewing&f=false	beer brewing	290 000	Google Scholar

Table 1. Literature search.

Appendix C

Week	To do	Done	Comment
3	Find a thesis topic. Start project plan, read 2 scientific articles. Start writing an introduction.	✓	
4	Read 2 scientific articles, first meeting with supervisor, second meeting with supervisor, gastronomy and engineering students. finalise project plan. Work on introduction for thesis paper.	✓	Deadline: ½ Meeting supervisor 24/1 Meeting with gastronomy students 27/1 Satisfied with 3 pages.
5	Change project plan according to the feedback, start with the practical part, contact gastronomy and engineering students working with us. Choose tools for the practical part together with engineering students. Create a plan		Meeting with project members 30/1
6	Plan together with gastronomy and engineering students on how to collect data. Finish the plan		
7	Data collection, cleanup, labelling. Visiting Klackabackens brewery. Data collection		study visit 14/2
8	Data collection. Machine learning algorithms training		
9	Machine learning algorithms training 2		
10	Comparing algorithms		
11	Testing if the results are as expected		
12	Eventual changes to thesis report. Insert base information from experiments to thesis report.		60% of the thesis done. Deadline: 27/3

Week	To do	Done	Comment
	Upload for midway seminar end of week		
13	Prepare for midway seminar		
14	Midway Seminar + eventual changes in thesis report		3/4 - 5/4
15	Finalise practical part		
16	Thesis report – write Analysis, Result		
17	Thesis report – write Discussion, look over the whole document.		
18	Self evaluation		Upload self-evaluation
19	Finalise Thesis Report and Submit		Deadline: 8/5
20	Do and Upload Opposition report		Deadline: 22/5
21	Prepare for the final presentation		
22	Final Presentation		29/5 – 1/6

Table 2. Detailed time plan for every week.