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Process Standardization of Hefeweizen Beer Incorporated with Mango Pulp

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Abstract
This research focuses on the development and process optimization of Mangoweizen Beer, a fruit-infused wheat beer created by blending traditional German Hefeweizen with natural mango pulp. Hefeweizen, a centuries-old German wheat beer style, is known for its fruity esters and cloudy appearance, making it an ideal base for fruit infusions. Mango, rich in sugars and volatile aromatic compounds, adds a tropical twist to the classic profile. A series of trials were conducted with varying mango pulp concentrations (20 mL, 30 mL, and 50 mL per 100 mL beer) to evaluate sensory appeal, chemical consistency, and microbial stability. The final formulation (1:1 beer-to-pulp ratio) was selected based on optimal taste, color, and mouthfeel. Chemical analysis showed 90–92% moisture, 0.2–0.4% protein, negligible fat, and an ABV of 4.5–5.2%. A carbonation level of 3.83 volumes CO_2 and pH between 4.0–4.5 ensured freshness and microbial safety. This paper presents detailed materials and methods, including market analysis, raw material procurement, proximate and microbial testing, and sensory evaluation. The findings demonstrate that Mangoweizen Beer is a promising innovation aligning with consumer trends for fruit-forward, craft alcoholic beverages.

Keywords: Hefeweizen, mango pulp, craft beer, fermentation, sensory analysis, microbial safety

Introduction
The craft beer industry is continually adapting, with new styles and flavors emerging to cater to consumers' evolving preferences. A notable trend in brewing is the incorporation of fruits to craft distinctive, refreshing beers. Among these innovations, fruit-infused wheat beers are gaining traction due to their mild bitterness, smooth texture, and appealing fruity aroma. This research highlights the development and assessment of Mangoweizen Beer, a unique fruit beer that combines traditional Hefeweizen with natural mango pulp. Hefeweizen, a popular German wheat beer, is celebrated for its hazy appearance, light body, and fruity undertones. Its gentle flavor and naturally sweet finish make it an ideal base for adding fruity elements. Mango, a tropical favorite known for its rich scent and juicy flavor, complements the mild and slightly spicy notes of Hefeweizen. This fusion results in an innovative twist on a classic beer style, yielding a refreshing, flavorful drink that resonates with diverse beer enthusiasts. The objective of this study is to craft a well-balanced mango-flavored wheat beer that preserves the essential characteristics of Hefeweizen while infusing the sweetness and freshness of mango. The brewing process involved a blend of wheat and barley malts, mild hops for bitterness, and a particular yeast strain for fermentation. Following fermentation, natural mango pulp was incorporated into the final product. Various trials were conducted to determine the optimal amount of mango pulp for achieving the desired flavor, leading to a final blend based on taste and appearance assessments. This research paper outlines the entire journey of creating Mangoweizen Beer, from choosing ingredients and brewing to blending and evaluating the final product. It includes a fundamental analysis of taste, look, and shelf stability, as well as insights from participants in the brewing and testing phases. The findings aim to demonstrate that traditional beer styles can effectively merge with fruit flavors to produce exciting new beverages. Mangoweizen Beer exemplifies how minor adjustments and careful ingredient selections can create entirely new and enjoyable beer experiences, thereby encouraging further innovation in the realm of fruit-flavored beers within the current craft beer market.

Materials and Methods
1. Market Survey
There was a market survey carried out using a Google Form to obtain consumer feedback on fruit-beer. The survey was sent to different respondents to assess their interest in fruit-beer and diffrent beer styles and most loved flavours. The feedback provided insightful information on market trends that enabled us to identify opportunities and gaps for the development of product.

2. Procurement of Raw Materials
The ingredients were carefully selected to maintain authenticity and consistency:
- **Wheat Malt:** 3 kg
- **Pilsner Malt:** 2.5 kg
- **Munich Malt:** 0.5 kg
- **Polish Magnum Hops:** 23 g
- **Munich Classic Yeast:** 12 g
- **Mango Pulp (13° Brix):** 10 L
- **Water:** Filtered municipal supply

3. Trials Taken and Devolpment of Product
The creation of Mangoweizen Beer started with brewing a classic Hefeweizen using a homebrewing technique. Hefeweizen, a traditional German wheat beer, was chosen for its low bitterness, fruity aroma, and cloudy look, making it an ideal base for fruit integration. The brewing process involved selecting specific malts to achieve the desired body and flavor. A combination of 3 kg of wheat malt provided the signature smooth, creamy texture, along with 2.5 kg of Pilsner malt for a light foundation and 0.5 kg of Munich malt to introduce a hint of sweetness and depth. Water was added according to standard ratios to facilitate mashing and boiling. For bitterness, 23 grams of Magnum hops were

added during boiling, contributing a clean bitterness that complemented the Hefeweizen style. Following the boil, the wort was cooled and transferred for fermentation, where dry Munich Classic yeast was introduced. This yeast is recognized for its ability to generate fruity and spicy esters, enriching the beer's complexity. After fermenting completely, the Hefeweizen was ready for fruit blending experiments. To craft Mangoweizen, varying amounts of mango pulp were incorporated into the finished beer to find the ideal flavor balance. The first trial with 20 mL of mango pulp yielded minimal flavor and color enhancement. The second trial with 30 mL showed slight improvements, but still lacked a significant mango presence. The final trial, using 50 mL of mango pulp, resulted in a robust mango flavor and vibrant color, deemed the most enjoyable mix. Ultimately, the final Mangoweizen was created by blending 10 liters of mango pulp with 10
liters of Hefeweizen, resulting in a total of 20 liters. The beer was bottled in PET containers to maintain freshness, ensure safe storage, and achieve proper carbonation. This approach successfully merged traditional brewing methods with a fruity twist, producing a refreshing and flavorful craft beer.

To identify the optimal beer-to-pulp ratio, three experimental batches were developed:

	Trial Hefeweizen Beer (mL) Mango Pulp (mL)		Outcome
1	100	20	Mild tanginess
2	100	30	Balanced flavor
3	100	50	Best flavor & texture

Trial 3 was chosen for its superior sensory characteristics and market readiness.

4. Chemical Analysis

The chemical analysis of sample 3 that was most approved as per the sensory evaluation was done. The chemical parameters were moisture content, Alcohol by volume, protein, fat, total ash content, carbohydrate and fiber.

The moisture content was measured using Oven drying method. The estimation of protein was measured using Kjeldahl method. The fat and carbohydrates were measured using Soxhlet method and Anthrone method respectively. The product was converted to ash in the muffle furnace. The crude fiber was measured using Fiber analyzer

- **Moisture:** 90–92%
- **Protein:** 0.2–0.4%
- **Fat:** 0%
- **Ash:** 0.1–0.2%
- **ABV (Alcohol by Volume):** 4.5–5.2%
- **pH:** 4.0–4.5
- **Brix of Mango Pulp:** 13°
- **CO_2 Volume:** 3.83

5. Microbial Analysis

Microbial analysis was conducted to verify the safety and stability of Mangoweizen Beer throughout its production. Samples were taken from both the fermented Hefeweizen and the finished blended beer to monitor for microbial contamination. Total plate counts and selective media were utilized to identify common spoilage organisms, including Lactobacillus, Pediococcus, and wild yeasts. Special care was concentrated on the point of mango pulp addition, as the fruit can introduce natural sugars and moisture that could encourage microbial growth. To address this risk, rigorous sanitation practices were implemented during the blending and bottling processes. All equipment was thoroughly cleaned and sanitized with approved food grade disinfectants. The final product's pH was maintained within a safe range (4.0–4.5), which helped to inhibit pathogenic bacteria. The final microbial analysis indicated no contamination, confirming that the beer was microbiologically safe and suitable for consumption when stored properly.

- **Total Plate Count:** Satisfactory
- **Yeast & Mold:** Absent
- **Lactic Acid Bacteria:** Within permissible limits
- **Hygiene Protocols:** Strict sanitation procedures followed

Results and Discussion

1. Sensory Evaluation Results

The Mangoweizen Beer underwent a comprehensive sensory evaluation to analyze its key organoleptic characteristics, including color, texture, flavor balance, sweetness, sourness, mouthfeel, and overall acceptability. This assessment employed a 9-point hedonic scale, where a score of 1 represented "Dislike extremely" and 9 represented "Like extremely." A group of 12 participants, ranging from untrained to semi-trained, took part in the evaluation. Each panelist received coded samples in neutral lighting, and palate cleansing was performed with water and unsalted crackers between tastings to ensure objective evaluations. The findings showed high levels of acceptability across all assessed parameters. The beer's color received an average score of 8, due to the bright yellow shade created by the wheat malts and mango pulp, which was well received by the panelists. The texture and mouthfeel were particularly well-rated, both scoring a 9, indicating the beer's smooth and consistent body, as well as its refreshing quality. The light, slightly creamy texture made it enjoyable to drink without feeling heavy. Flavor balance also received a score of 9, indicating that the combination of mango pulp and the Hefeweizen base produced a well-rounded flavor profile. The beer was recognized for its crispness and natural fruitiness, which complemented rather than overshadowed the malt foundation. Sweetness, resulting from both the malt and mango pulp, garnered a score of 7.8, suggesting it was pleasantly sweet without being overwhelming. Meanwhile, sourness scored the lowest at 7.4, yet still remained within an acceptable range, with a mild tartness adding complexity without being off-putting. The overall acceptability score of 8.2 indicated that Mangoweizen was very positively received. Most panel members valued the harmonious blend of fruit and malt flavors, the smooth texture, and the refreshing finish. These results imply that the Mangoweizen Beer formulation is sensorially appealing and aligns well with consumer expectations. Since all key attributes scored above 7, no significant reformulation is necessary. The product is ready for market introduction in its current form and has the potential for solid consumer approval.

				Sample Color Flavor Texture Mouthfeel	Overall acceptability
Control	7.57	7.25	7.20	7.425	7.36
Sample A	6.65	6.475	7.38	7.4	6.9
Sample B	7.3	8.233	7.6	7.94	7.84
Sample C	8	9	8	8	8.2

Discussion:

The sensory analysis clearly indicates that mango integration significantly enhanced the consumer appeal of the traditional Hefeweizen. The Munich Classic yeast used in fermentation contributed fruity esters that blended harmoniously with the tropical mango aroma, creating a pleasant and refreshing profile. The natural sweetness of mango balanced the low bitterness of the base beer, while the pulp's viscosity contributed to a rich, smooth mouthfeel. Compared to other fruit beers like those infused with guava or berries, Mangoweizen achieved superior scores in texture and flavor balance. Importantly, the 1:1 ratio avoided excessive sweetness, preserving the beer's drinkability. This demonstrates that the chosen formulation can appeal to both seasoned craft beer enthusiasts and newer audiences seeking approachable flavors.

2. Chemical Analysis Results

A chemical analysis was carried out on Mangoweizen Beer to assess its fundamental compositional traits and ensure the final product's quality and consistency. The moisture content was found to be around 90-92%, which is normal for beer and highlights its liquid characteristic. The fat content stood at 0%, affirming the beer's low-fat profile and clean finish. Protein levels were recorded at 0.3-0.4 g/100g; while this contributes little nutritionally, it plays a vital role in foam stability and mouthfeel. The ash content, which indicates the total mineral presence, was about 0.2 g/100g, suggesting a well-balanced amount of inorganic compounds. The alcohol by volume (ABV) was measured at 3.83%, which meets the expected strength for a sessionable craft ale. These chemical parameters confirm the product's quality and safety, indicating that Mangoweizen Beer adheres to acceptable standards for compositional integrity and consumer health.

Parameters	Final Product
Moisture Content (%)	~90–92%
Fat (g/100g)	0%
Protein (g/100g)	0.3-0.4%
Ash (g/100g)	0.2%
ABV	3.83 UNITS

Discussion:

The Mangoweizen beer exhibited a clean and stable chemical profile, aligned with food and beverage safety standards like those from the Codex Alimentarius and ASBC. The carbonation level of 3.83 volumes CO_2 contributed to a crisp mouthfeel, while the pH range of 4.0–4.5 ensured both freshness and microbial resistance. The absence of fat and low protein content also supports a desirable nutritional label. The alcohol content of 4.5–5.2% matched market expectations for sessionable fruit beers. These parameters confirm the feasibility of scaling up this formulation without compromising quality.

3. Microbial Analysis Results

Microbial analysis of the Mangoweizen Beer was carried out to assess its microbiological safety and shelf stability. Samples taken after fermentation and post-blending with mango pulp were tested for total plate count, yeast and mold, and lactic acid bacteria using standard culture methods. The results showed no detectable pathogenic or spoilage organisms in the final product. The pH level, maintained between 4.0 and 4.5, created an acidic environment that naturally inhibited microbial growth. The use of pasteurized mango pulp, sanitized equipment, and sterile PET bottle.

Discussion:

Microbial results validated the safety and shelf-stability of the final product. The low pH environment, combined with the natural preservation properties of the mango and pasteurization steps, helped mitigate contamination risks. Adherence to sanitation protocols ensured the absence of spoilage organisms such as molds and pathogenic yeasts. Literature suggests fruit beers are prone to microbial instability, yet the current process succeeded in overcoming these concerns, making Mangoweizen a reliable product for commercial distribution.

Conclusion

The creation of Mangoweizen Beer marks a significant innovation in the craft brewing industry by merging the traditional characteristics of German Hefeweizen with the tropical essence of mango pulp. Through meticulous formulation, blending, and optimization trials, a final product was developed that successfully combines the smoothness of wheat malt with the natural sweetness and vibrant aroma of mango. Sensory evaluations were essential in determining the ideal pulp-to-beer ratio, with the third trial (50 mL of mango pulp per 100 mL of beer) emerging as the most favorable in terms of flavor, color, and mouthfeel. Chemical analyses indicated the product's nutritional consistency, featuring high moisture levels, minimal fat content, moderate protein, and an alcohol by volume (ABV) of 3.83%. Microbial testing confirmed the product's safety, showing no contamination in any samples, thus validating the effectiveness of hygienic practices and processing conditions. Sensory assessments using a 9-point hedonic scale reflected high acceptability for various attributes, including flavor balance, texture, color, and overall satisfaction, with most ratings exceeding 7, indicating strong consumer appeal. This research illustrates the potential of incorporating fruit elements into classic beer styles to enhance their attractiveness and diversify flavor profiles. Mangoweizen Beer emerges as a distinctive beverage, providing a refreshing variation while adhering to quality and safety standards. It is well-suited for commercial launch, particularly in the expanding market for flavored and craft beers. With additional scaling and branding efforts, Mangoweizen could establish a solid presence in both niche and mainstream markets.

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