__Original Research Article__

Development of New Variant Beer Using Papaya

ABSTRACT

Beer becoming one of the ancient and most widely enjoyed beverages globally, iswitnessing a growing popularity in the form of functional brews. Nevertheless, thereisaconstraintonconductingastudyontheimpactofincorporatingfunctionaladjunctsat different stages of the production process and how this affects the final physical,chemical,andsensoryproperties.Thecurrentstudyexaminestheingredientsemployedandtheirdegreeofincorporationtoproduceafunctionalbeerwithbioactivecompounds, improved antioxidant activity, and increased flavor qualities. Beer hasbeenatrendwithaninfusionoffruitintheformofPiecesorextracts.Inaddition,they were successfully introduced into the various steps like wort boiling, fermentation,maturation, and packaging processes to enhance the consumer perception point ofviewandthemutualbenefitsofhealthsuchasheartdiseasesandStrokeasimprovement of Bone Density.Beer samples were made with the addition of papayapulpin differentratios in17 combinations/replicants.

Keywords:*Fruit-infusedbeer;Brewingtechniques;Sensoryassessment;Fruitenzymes*

1. INTRODUCTION

This study explores the various ranges of consumption of beer with an infusion of fruit, at an adequate amount which enhances the taste perception and also makes more attraction on behalf of refreshment. The process of making beer with fruit is similar to making traditional beer. Fruit is typically added during the fermentation stage. This allows the fruit sugars to ferment and mix with the beer, creating a unique flavour profile [1]. In the past, people did not consider the various advantages of fruits. Currently, there is a significant amount of public interest in the health advantages, particularly in terms of medical and nutritional properties. The increasing popularity of fruit-based beers can be attributed to their unique flavours and nutritional benefits [2].Fruits such as apricots, peaches, and mangoes have been effectively integrated into the process of making beer, providing a sustainable and interdisciplinary approach to brewing [3]. The inclusion of these fruits significantly influences the beer's colour, taste, and aroma characteristics, hence enriching the overall sensory perception. In addition, fruit beers can offer substantial amounts of beneficial components such as vitamins, minerals, and antioxidants, rendering them 1 a more healthful option compared to conventional hop-based beers [4]. By incorporating fruits into the brewing process, firms may diversify their product offerings, meet changing consumer demands, and perhaps decrease reliance on synthetic ingredients such as hops, thus promoting a more environmentally friendly brewing sector [5].The fruit can be added in various forms including fresh, frozen, pureed, Pulp or juice [6].The most popular alcoholic beverage worldwide is beer. It is produced by fermenting cereals, primarily barley. Beer is regarded to be safer and more nutritive than all other alcoholic beverages. Beer is considered safe as it contains less alcohol content and high nutritive value [7]. Brewing Papaya as the main ingredient to enhance the quality and distinct flavour. Papaya beer is alsoknown for its health benefits such as Papaya is rich in vitamins, and antioxidants and has been shown to have anti-inflammatory and digestive properties [8]. This Research will reveal the new variant type of Beer for taste perception and consumption. Infusion of papaya into beer will lead to the breakdown of enzymes to the complex sugars in the wort making them more accessible to the yeast. This can result in a more efficient fermentation process and a higher quality beer. The beer is typically made by adding papaya puree or juice to the beer during the fermentation 2 process. This imparts a unique flavor and aroma to the beer, with a hint of tropical sweetness and tanginess. According to beer purity law, beer can be made by using barley, hops, yeast, and water as main ingredients [9]. Herbs are plants that widely occur in nature and have medicinal properties and are also used in culinary practices. Using papaya fruit as an ingredient in brewing recalls the ancient culture and tastes of beer along with its medicinal values. Herbs are responsible for the development of taste, aroma, and overall flavor of the beer by the presence of secondary metabolites in them [10].Along with these, herbs also develop medicinal benefits in the product formed. The addition of this ingredient can have health-improving properties for the human body. In earlier beer brewing, various herbs are used to make a beer. This study also examines several tests related to the Sensory and quality attributes of Beer to enhance the maximum health benefits of Antioxidants and rich in different bioactive compounds that have medicinal benefits[2].

Objectives of this experiment was:

1. To optimize the process parameters for the development of Beer.
2. To evaluate the physio-chemical and sensory attributes of Papaya Beer

2. MATERIALSANDMETHODS

2.1 Materials

ThewortfermentationprocessutilizedSaccharomycescerevisiaeyeastobtainedfromMerck Life Sciences. The yeast was hydrated in distilled water for 30 minutes at atemperature of 25 °C. After that, it was added to the wort at a concentration of 0.58gramsofdrymatterperliter,followingtheguidelinesprovidedbythemanufacturer.

2.1.1 Rawmaterial

Papaya (Carica papaya) is a tropical fruit, semi-ripened papaya was collected from thefields of LPU, Phagwara. Grown variety of IRIS Hybrid Papaya RC-217 in November2023,whichwasstoredinZNBFcamberforaweekandimmediatelyexactedintheformof pulp using a fruit blender. The extract content in fruit juices were: 16%w/w of yellowjuice. Barley is purchased from local agricultural market from last year (2022) and hopswaspurchasedfromtheC&Chopfarms,Yakima,Washington,respectively.Themaltwasmashedusing alaboratorygrindermanufacturedbyBrabendercompany(India),specificallydesignedforcrushingmalt togetthedesired consistency.

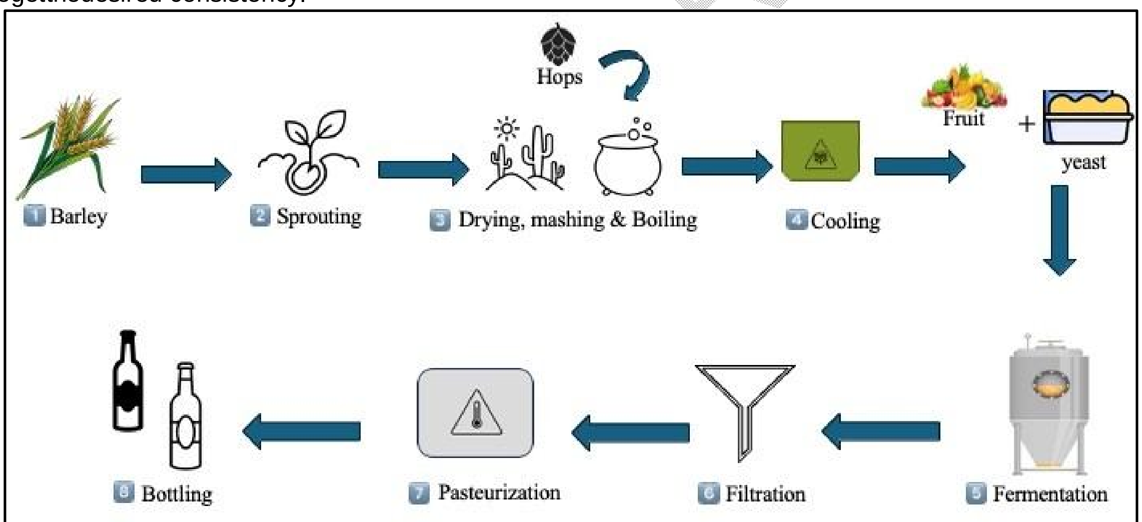

Fig1.FlowChartrepresentingtheInfusionprocessinBeer

2.2 BrewingTechnology

A total of 5 kg of malt and 17.5 kg of water were combined at a weight ratio of 1:3.5 (malt: water)forthepurposeofmashing.Theinfusionmashingprocesswascarriedoutinacontrolledlaboratoryenvironment [11]. Waterwas heated to a temperature of 67°C, followed by theaddition of malt while holding the temperature for 70 minutes. Subsequently, the temperature wasraisedto76°Cwithastepdurationof10minutes.Thepreparedmashwasfilteredwithfilterpaper,and the resulting wort was boiled with 1 g/L of hops for 60 minutes. The boiled wort was cooled toa temperature of 25 °C and filtered once more to obtain the control wort. The extract content wasdeterminedtobe12°Bxrefractometer accordingtoit.TheprocedureforpreparingspecificexperimentalvariationsisoutlinedintheExperimentalplan.Thefermentationprocesswasconductedin 2L glass fermentationflasks [12].

2.3 Analyticalmethods

2.3.1 Basicphysicochemicalparameters

Extract wort was measured in a Hydrometer for specific gravity to calculate thedegree of alcohol percentage in beer before fermentation and after fermentation, Tssof wort was checked within value using 12°Bx and the pH value of beer was measuredwith an MP 240 pH-meter. Foam characteristics will result in the creation of carbondioxide gas that results in bubble formation as this can be done by keeping the beeratRoomtemperature.Allthemeasurementswereanalyzedintriplicateform.Table 1 Representing the particular proportion of papaya pulp used in the beer along with Temperature and Time, where PB represents the Papaya Beer with number as the replicant ratio for making.

Table 1: Proportion of papaya pulp used in the beer

S/NO	A:Fruit	B:Temperature	C:Time
	Pulp%	**°C**	**InDays**
PB1	5	20	8
PB2	20	20	8
PB3	5	35	8
PB4	20	35	8
PB5	5	20	24
PB6	20	20	24
PB7	5	35	24
PB8	20	35	24
PB9	0	27.5	16
PB10	25.1134	27.5	16
PB11	12.5	14.8866	16
PB12	12.5	40.1134	16
PB13	12.5	27.5	2.54566
PB14	12.5	27.5	29.4543
PB15	12.5	27.5	16
PB16	12.5	27.5	16
PB17	12.5	27.5	16

CalculationofAlcoholpercentage(ABV%)

Alcohol content Determination: A hydrometer is an instrument utilized for the precise measurement of density. Brewing hydrometers are used to measure the specific gravity of a liquid, which represents the ratio of the liquid's density to that of water. An object with a specific gravity (SG) less than one is less dense than water and will therefore float, whereas an object with an SG larger than one is denser and will sink.

The hydrometer is a precisely calibrated object that submerges to a specific depth based on the density of the liquid it is placed in. The density of a liquid can be determined by measuring its displacement. Place the just disinfected hydrometer into its designated tube. Extract a little portion of your beverage from the center using a sampler. Fill the hydrometer tube until the hydrometer is able to float without any obstruction, and then stop filling. If your equipment has been properly cleaned, it is acceptable to return any excess liquid. Position the hydrometer on a horizontal and even surface, then delicately rotate it in both directions to eliminate any air pockets that might have formed on its exterior. Verify that the hydrometer is buoyant and not in contact with the inner walls of the hydrometer tube. Observe the hydrometer reading by looking at the measurement at the lowest point of the curved surface of the liquid, while keeping your eyes at the same level as the hydrometer. The meniscus is a concave surface formed due to the cohesive forces of surface tension, which can have a significant impact.nThe magic number is approximately 131.25. Thepercentage of alcohol can be determined using the following formula:The wortwas assessed using a hydrometer to determine its initial specific gravity prior tofermentation. After the secondary fermentation, the beer was examined usingspecificgravity measurements.

$$ABV\% = Finalspecificgravity - Initialspecificgivity \times 131.25$$

Analysisofbeerbitterness(IBU)

In order to assess the level of bitterness in the fermented beers, a volume of 10mL of beer without gas was transferred to Falcon tubes with a capacity of 35mL. Subsequently, 0.5 c of a hydrochloric acid solution with a concentration of6NHClwasaddedtothetube,followedbytheadditionof20mLofisoacetate.Thetubeswereshakencontinuouslyforadurationof10 minutes.Subsequently,10 mL of the sample were transferred to Falcon centrifugation tubes with acapacityof15mLandsubjectedtocentrifugationataspeedof3000revolutionsper minute for a duration of 5 minutes. A specimen for analysis was obtainedfrom the isoacetate layer and quantified using spectrophotometry by detecting its absorbance at a wavelength of 275 nm. The standard used was pure isoacetate.

TheIBUcanbedeterminedusingtheformula:

$$IBU=50 * A \text{ (A–absorbance at275nm)}$$

Totalpolyphenolscontentandantioxidativeactivity

The Folin-Ciocalteu (F-C) spectrophotometric methodwas employed to measure the overallpolyphenoliccontentofthebeer.CuvetteswerefilledwithbeersamplesandF-Creagentusinga pipette(Jurić et al., 2015). After a duration of 3 minutes, a volume of 1 millilitre of a sodiumcarbonate(Na2CO3)solution,whichiscomposedof20%sodiumcarbonatedissolvedinwater,was added. Additionally, a volume of 2 milliliters of distilled water was also added. Themeasurement of absorbance at a wavelength of 765 nm was conducted after a duration of 1hour,andthefindingswerereportedasmilligramsofgallicacidequivalents(GAE)perliterofbeer.Thedatawererepresentedastheaveragevalueforthreemeasurements(Montanarietal.,1999).

The antiradical activity was assessed by employing a DPPH% assay, 0.1 mL aliquotsofbeerwerecombinedwith2mLofa0.04mmol/LDPPH%solutioninmethanol,alongwith 0.4 mL of water. Following a 10-minute period of incubation at ambient temperature, theabsorbancewasquantifiedusingaspectrophotometeratawavelengthof517nm,(Yen&Chen,1995) utilizing disposable polystyrene cuvettes. A calibration curve was generated using aTrolox solution with a concentration of 0.05 × 10–1 mmol/L. The data were quantified as theantioxidative capacity per liter of the beer, expressed in millimoles of Trolox equivalent (TE)perliter(mmolTE/L).Themeasurementswereconductedthreetimes.(Kawa-Rygielskaetal.,2019)

ColordeterminationofBeer

Determination of color of beer using EBC method where the 5ml of sample is taken anddegassed and filled in a cuvvet directly to measure the Absorbance in Spectrophotometer at430 nm.

Calculation of$EBC=25.d.A430nm$

Where A430nm = the measurement of Absorbance at λ = 430nm.d= Dilution factor of beer

Sensoryevaluation

Followingfermentation,theobtainedproductsweresensoryevaluated,assessingflavour-asensoryattributeresultingfromstimulationoftheolfactoryreceptors in the nasal cavity and eyes in determining the certain color (1 -unpleasant,10-verypleasant);Taste - a sensory attribute resulting fromstimulationofthegustatoryreceptorsinthe oralcavitybycertainsolublesubstances(1-unpleasant,10-verypleasant);Aroma-acombinationofflavourand taste. Bitterness - a sharp and bitter taste felt with receptors concentratedtowards the back of the tongue and throat (1 - not present, 10 - very strongbitterness); freshness - as determined by the alcoholic strength, CO2 content,and hopping level of the beer (1 - stale, 10 - fresh); general impression - theinteractionofallsensorysignals(1- verybad,10 -verygood).

3. RESULTANDDISCUSSION

Basicphysicochemical parameters of Beer such as pH value, Colour,Bitterness,TSS and Alcohol

The brewed beer was analyzed for the concentration of alcohol. The inclusion of juices facilitated the production of beer with a greater ethanol concentration in comparison to the beer without juices. A study conducted by Martínez, Vegara, Martí, Valero, & Saura (2017) found that adding persimmon fruit during the brewing process increased the alcohol percentage in beer. Furthermore, the ethanol percentage in the brewing process escalated as more persimmon fruits were added. Nevertheless, the inclusion of Cornelian cherry fruit juice at 50% of the wort volume resulted in the production of beer with a lower alcohol concentration compared to the beer brewed In our study with a 10% addition of the papaya pulp. This is despite the fact that the initial wort extract was higher (Martínez, Vegara, Martí et al., 2017). Additional studies on papaya-infused beer revealed that the alcoholic content of the beers varied between 2.55 and 4.55, indicating varyinglevels of alcohol concentration. This parameter is vital as it directly influences the taste, texture, and overall influence of the beer. The alcohol content in the 17 samples ranged from 4.58% to 5.45%, with the lowest and highest values being observed. The sample with PB1 has a lower percentage of 4.58%, whereas the sample with PB4 has a higher percentage of 5.45%. as shown in Table 2 for further understanding.

The initial pH value of PB4 was 5.81. However, the addition of Papaya pulp caused a considerable fall in pH due to its naturally low pH of 2.9 on average(Gasiński et al., 2020)(Patidar et al.,2016). The PB15 exhibited the maximum degree of bitterness. The presence of over ripened Papaya fruit juice, which lacks bitterness qualities, may have caused a decrease of 2 units in the hopped wort's bitterness level.The pH level of beer denotes its amount of acidity or alkalinity,(Weiß et al., 2002) which has an impact on its taste, stability, and microbial activity. Beer typically has a pH range of 3 to 4.5, making it slightly acidic. Below are the measurements for the beer samples. The range of acidity levels observed is from 3.32 to 4.22. PB4 has a pH of 3.32, indicating a higher level of acidity. On the other hand, PB2 has a pH of 4.22, indicating a lower level of acidity.Typically, the brewing method produces beer with a lower sugar content compared to following Table1. This is because fruit pulp is added to the beer after the initial fermentation, whereas in PB15, the pulps are added before fermentation, allowing the yeast to convert the sugars in the juices into alcohol.The process of mashing malt involves the breakdown of starch, whichleads to the formation of fermentable sugars like as maltose, glucose, and maltotriose. However, this process also produces non-fermentable carbohydrates such dextrins(Jameson et al., 2001)(Kawa-Rygielska et al., 2019). The presence of these carbohydrates might impact the sensory characteristics of beer, depending on their concentration. Controlling the concentrations of these substances is essential to ensure the optimum quality of the end product.(Li etal., 2020)(Krebs et al., 2019) The pH of fermented worts reduced somewhat when papaya pulp was added, whereas in the sample it decreased by 2 units. The acidity of fruit beer is influenced by the specific type and amount of fruits incorporated into the wort, as well as the fermentation process, which reduces the pH of the beer.The beer PB15 exhibited the highest level of bitterness, reaching a range of 29. In contrast, the lowest level of bitterness was seen in beers PB14.The study findings revealed a reduction in bitterness following fermentation, observed in both the control samples and the majority of the other samples. The bitterness of beer is caused by hops, which also have antimicrobial properties that help to preserve the beer and influence its sensory characteristics such as taste and Aroma.(Honget al., 2021)(Díaz et al., 2023)The latest studies on the sensory assessment of several categories of beer have shown that customer preferences are primarily centered around goods with a minimal degree of bitterness.Therefore, the Papaya beer produced in our study has the potential to be essentially accepted in this aspect.

Table 2. Physicochemical Parameters of Alcohol, pH, TSS, and Bitterness ofPapayaBeer

Sample	Alcohol%	pH	TSS(°Brix)	IBU
PB1	4.58	3.76	11.7	21
PB2	5.12	4.22	12.4	18
PB3	4.85	3.95	13.3	24
PB4	5.45	3.32	10.9	26
PB5	4.93	3.78	12.1	22
PB6	5.37	4.10	11.6	20
PB7	4.79	3.55	13.0	17
PB8	4.90	3.68	11.2	19
PB9	5.22	3.89	12.8	25
PB10	4.67	3.49	12.0	23
PB11	5.10	4.05	11.9	16
PB12	4.75	3.60	12.5	27

PB13	5.00	3.72	10.5	28
PB14	4.88	4.00	13.1	15
PB15	5.30	3.80	12.7	29
PB16	4.82	3.65	11.4	22
PB17	5.25	3.90	12.3	21

3.1 Concentrationoftotalpolyphenolsandantioxidativeactivity

Wort supplemented with papaya pulp had a greater overall concentration ofpolyphenols compared to those without any fruit pulp. The wort had the highestoverall polyphenol concentration. The study findings indicate that fermentingbeer worts without any additional substances, as well as those with the inclusionof Papaya fruit pulp solutions, leads to an elevation in the overall polyphenolcontentinthefinal product.(Kawa-Rygielskaetal.,2019)

The final concentration of total polyphenols in the brewed beer was established based on the combination of the production process and the type of juice added. The polyphenol levels in beer without juice arose The primary sources of polyphenolic compounds in beer are malt (75%) and hops (25%). (Veljovic et al., n.d)These compounds have a significant role in determining the beer's color, flavor, and bitterness. Furthermore, it is asserted that they constitute a significant origin of antioxidants in beer. A study conducted by researchers showed that incorporating persimmon fruits during the brewing process resulted in a decrease in the concentration of total polyphenols in the final product(Leitao et al., 2011). Furthermore, the reduction in polyphenol concentration was more pronounced with a higher amount of fruit added. This could be attributed to the absence of phenolic compounds in persimmon fruits. A study investigating the effects of adding goji berries to beer found that the beer with goji berries had a higher concentration of phenolic compounds compared to the regular beer.(Ducruet et al., 2017) Furthermore, the findings presented by these authors align with the results of our study, which demonstrated that incorporating fruit juices during the secondary fermentation stage of beer production resulted in a higher concentration of these compounds compared to adding fruit juices to the wort prior to theinitiation of primary fermentation. The findings of our investigation suggested that the inclusion of juice derived from all evaluated Papaya pulp varieties enhanced the antioxidative characteristics of the worts, as indicated in Table 3.

Table 3. Antioxidant activity and polyphenols of Papaya Beer

BeerType	Polyphenol Concentration (mgGAE/L)	DPPH(mmolTE/L)
PB1	185.0±6.0	1.46±0.11
PB2	265.0±7.0	2.07±0.10
PB3	220.0±5.0	1.55±0.08
PB4	235.0±6.5	1.74±0.07
PB5	240.0±7.0	1.80±0.05
PB6	230.0±3.0	1.70±0.10
PB7	188.0±6.5	1.43±0.09
PB8	268.0±7.5	2.06±0.11
PB9	217.0±4.5	1.52±0.06
PB10	232.0±6.0	1.71±0.05
PB11	232.0±6.0	1.77±0.04
PB12	184.0±6.3	1.52±0.10
PB13	273.2±6.9	2.10±0.09
PB14	229.1±6.1	1.72±0.06
PB15	238.4±6.8	1.81±0.04
PB16	224.8±2.9	1.80±0.09
PB17	215.9±4.8	1.58±0.07

Values areexpressed as the mean (n = 3) ± standard deviation, Mean valuesstatisticallydifferent($p < 0.05$)

The highest level of antioxidative capability was measured. Our study demonstrates that fermentation leads to an enhancement in the antioxidative capabilities of the produced beer. Furthermore, these capabilities are influenced by both the beer production technology and the type of juice added.The beer brewed with exhibited somewhat reduced capabilities. However, the antioxidant capacity of beer was higher when coral fruit juice was added. Fruit juices and other liquids contain significant amounts of natural antioxidants, such as polyphenols. Beer is an excellent provider of antioxidants, and the specific types of antioxidants it contains are influenced by both the ingredients used and the production methods utilized. Prior studies conducted by other researchers have also shown that incorporating fruits into the brewing process enhances the antioxidative qualities of beer compared to the technique that does not involve their incorporation.(Yin et al., 2021) Nevertheless, their study on beer infused with goji berries and their investigation on beers made with persimmon fruits revealed that the beers they created had a reduced level of antioxidant activity compared to the beer generated in our trial, which contained papaya pulp. Previous studies have examined the antioxidative activity of both light and dark beer, (Zhao, 2014)but the activities observed in those studies were found to be less potent than the activities revealed in our own investigation. Comparing our study results with existing literature findings leads to the conclusion that Papaya can be suitable ingredients in the technology of fruit beer production, as they facilitate the brewing of beer with potent antioxidative properties.

3.2 Olfactoryanalysis

Over all the sensory attributes of spirits can be associated with specific volatile compounds like terpenes, which contribute to the sweet and citrus aromas observed in certain types of spirits, Differences in the composition and concentration of volatile compounds lead to variations in spirit flavours and aromas during sensory evaluations. Papaya-infused Beer samples were sensory analyzed with 10 members with prior information to be prepared. Sensory analysis was done on May 2024, LPU Punjab. Acceptance of top five samples are PB9, and PB3 whereas mostly disliked by the panellist is PB7 & PB 13. Furthermore findings are mentioned in Table 4.

Table 4. Sensory response of the beer withpanellist of 10 members.

BeerType	Aroma	Color	Clarity	Taste	Overall Impression
PB1	2.56±0.29	3.00±0.41	4.44±0.24	3.56±0.24	3.44±0.50
PB2	4.00±0.33	4.22±0.28	3.89±0.20	4.00±0.23	4.22±0.22
PB3	4.44±0.24	4.33±0.33	2.78±0.22	4.44±0.24	4.56±0.18
PB4	3.44±0.24	3.11±0.31	4.22±0.24	3.78±0.22	3.67±0.24
PB5	4.00±0.23	4.11±0.20	3.11±0.33	3.89±0.20	3.78±0.32
PB6	3.89±0.42	3.89±0.20	3.00±0.24	3.44±0.18	3.89±0.39
PB7	2.60±0.25	3.05±0.38	4.50±0.22	3.60±0.20	3.50±0.45
PB8	4.05±0.30	4.25±0.25	3.85±0.18	4.05±0.20	4.25±0.20
PB9	4.40±0.20	4.30±0.30	2.80±0.20	4.40±0.20	4.60±0.15
PB10	3.50±0.20	3.10±0.28	4.20±0.20	3.80±0.18	3.70±0.20
PB11	4.00±0.20	4.10±0.18	3.10±0.30	3.90±0.18	3.80±0.28
PB12	3.90±0.40	3.90±0.18	3.00±0.20	3.40±0.15	3.90±0.35
PB13	2.55±0.28	3.00±0.40	4.45±0.23	3.55±0.23	3.45±0.48
PB14	4.00±0.32	4.20±0.27	3.88±0.19	4.00±0.22	4.20±0.21
PB15	4.43±0.23	4.32±0.32	2.77±0.21	4.43±0.23	4.55±0.17
PB16	3.43±0.23	3.10±0.30	4.23±0.23	3.77±0.21	3.66±0.23
PB17	4.00±0.22	4.12±0.19	3.12±0.32	3.88±0.19	3.78±0.31

Values areexpressed as the mean (n = 3) ± standard deviation. Mean values are statisticallydifferent(p < 0.05).

4. CONCLUSION

The beer samples display a reasonable range of alcohol levels, ranging from 4.58% to 5.45%, which is common for most commercial beers. pH Levels: The pH readings range from 3.32 to 4.22, showing that all samples exhibit a slightly acidic nature. The presence of acidity is a normal characteristic of beers and it has a significant impact on their stability and flavour characteristics. Measurement of the concentration of dissolved solids in a substance: The Total Soluble Solids (TSS) levels, measured in °Brix, vary between 10.5 and 13.3. The sugar level of the beers directly affects their sweetness and mouthfeel. Bitterness (IBU): The IBU values vary from 15 to 29, indicating a spectrum of bitterness levels. This particular selection enables the creation of several flavour profiles, accommodating a wide range of customer preferences. The beer samples contain beneficial antioxidants, as indicated by the high polyphenol concentration and DPPH (antioxidant activity) values. The polyphenol concentration varies between 184.0 and 273.2 mg GAE/L, while the DPPH values vary from 1.43 to 2.10 mmol TE/L. The presence of antioxidants in beer contributes to the positive effects on health that are linked with moderate intake, as well as influencing the beer's capacity to maintain its flavour over time. The beer samples exhibited notable differences in their physicochemical attributes, polyphenol antioxidant concentration, and sensory qualities. Brewers may satisfy a variety of consumer tastes by modifying specific factors to boost desired traits, thanks to this diversification. These beer products are enhanced by the presence of beneficial antioxidants, which contribute to possible health advantages and increase their worth. In summary, the research offers useful information for improving beer production and guaranteeing the creation of high-quality products that satisfy consumers.

REFERENCES

1. Dennenlöhr J, Thörner S, Manowski A, Rettberg N. Analysis of selected hop aroma compounds in commercial lager and craft beers using HS-SPME-GC-MS/MS. Journal of the American Society of Brewing Chemists. 2020;78(1):16-31.
2. Nardini M, Garaguso I. Characterization of bioactive compounds and antioxidant activity of fruit beers. Food chemistry. 2020;305:125437.
3. Kerimbayev AA, Akhmetzhanov AA, Iztayev AI, Baigaziyeva GI, Kekibaev AA, Нетрадиционного П, ПроизводствеПива СВ, Керимбаева АА, Ахметжанова АК, Изтаев АИ, Байгазиева ГИ &Кекибаева АК. Using of nontraditional raw materials in beer production. The Journal of Almaty Technological University. 2023;30(1):12-8.
4. Ekberg J, Gibson B, Joensuu JJ, Krogerus K, Magalhães F, Mikkelson A, Seppänen-Laakso T, Wilpola A. Physicochemical characterization of sahti, an 'ancient'beer style indigenous to Finland. Journal of the Institute of Brewing. 2015 Oct;121(4):464-73.
5. Sohrabvandi S, Mortazavian AM, Rezaei K. Health-related aspects of beer: A review. International Journal of Food Properties. 2012;15(2):350-73.
6. Archana G, Gaurav S, Shruti M, Sarita M, Anuradha S, Kumar DM. Beer Production By Fermentation Process: A Review. Journal of Microbiology, Biotechnology & Food Sciences. 2024 Feb 1;13(4).
7. Albanese L, Ciriminna R, Meneguzzo F, Pagliaro M. Innovative beer-brewing of typical, old and healthy wheat varieties to boost their spreading. Journal of cleaner production. 2018 Jan 10;171:297-311.
8. Cho JH, Kim ID, Dhungana SK, Do HM, Shin DH. Persimmon fruit enhanced quality characteristics and antioxidant potential of beer. Food science and biotechnology. 2018 Aug;27:1067-73.
9. Veljovic M, Despotovic S, Pecic S, Davidovic S, Djordjevic R, Vukosavljevic P, Leskosek-Cukalovik I. The influence of raw materials and fermentation conditions on the polyphenol content of grape beer. InProceedings of the 6th Central European Congress on Food, CEFood 2012.
10. Takoi K, Koie K, Itoga Y, Katayama Y, Shimase M, Nakayama Y, Watari J. Biotransformation of hop-derived monoterpene alcohols by lager yeast and their contribution to the flavor of hopped beer. Journal of agricultural and food chemistry. 2010 Apr 28;58(8):5050-8.
11. Gasiński A, Kawa-Rygielska J, Szumny A, Czubaszek A, Gąsior J, Pietrzak W. Volatile compounds content, physicochemical parameters, and antioxidant activity of beers with addition of mango fruit (Mangifera Indica). Molecules. 2020 Jul 2;25(13):3033.
12. Kawa-Rygielska J, Adamenko K, Kucharska AZ, Prorok P, Piórecki N. Physicochemical and antioxidative properties of Cornelian cherry beer. Food chemistry. 2019 May 30;281:147-53.