Original Research Article

Production and Evaluation of Alcohol-Free Beer and Wine from Tropical Raw Materials

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ABSTRACT

Aim: The recent increase in demand of non-alcoholic beverages (alcohol-free beer and wine) due to health reasons, religious doctrines, tribal influence and personal perception in the past few years, has triggered research interest in alcohol removal and separation processes. This study is aimed at producing and evaluating alcohol-free beer and wine using a simple distillation technique.
Study design: This study was made to fit into using a combination of T-test and one way Analysis of Variance.
Place and Duration of Study: The research was carried out at laboratory of Department of Food Science and Technology, Federal University of Technology, Owerri, Nigeria, between February 2018 and November 2018.
Methodology: The physicochemical properties of pineapple juice and sorghum wort as well as pineapple wine and sorghum beer were evaluated and the parameters measured were pH, brix, total titratable acidity, total soluble solids, specific gravity, ethanol content, esters and higher alcohols.
Results: Wine from pineapple juice and beer from sorghum wort were dealcoholized using distillation technique to obtain a dealcoholized wine and dealcoholized beer. The dealcoholized products were also evaluated for pH, brix, total titratable acidity, total soluble solids, specific gravity, ethanol content, esters and higher alcohols using recommended methods. Results showed that significant difference (*P*= *.05*) exists between dealcoholized products and their corresponding wine and beer for pH, brix, titratable acidity and specific gravity.
Conclusion: The dealcoholization process performed using simple distillation technique caused complete removal of ethanol from pineapple wine and sorghum beer. Higher alcohols and esters which contributes significantly to the sensory quality in alcoholic beverages were also completely lost as a result of the distillation operation. Hence, flavour enrichment may be required to produce a pleasurable and delicious alcohol-free products.

Keywords: alcohol-free, dealcoholized beer, dealcoholized wine, distillation, pineapple wine, sorghum beer

1. INTRODUCTION

Beer and wine are alcoholic beverages produced from fermentation of cereal-wort and fruit juices respectively. Beer is a generic term used to describe alcoholic beverage made from cereal grains especially barley, in the form of barley malt [1]. The production of beer from malted cereal grains is referred to as brewing. While beer has been made from different grains through ages, barley remains the world's classical brewing cereals [2] owing to its high enzyme content (which facilitates the breakdown of the starch into fermentable sugars) and less problem in filtration being a covered caryopsis as well as its composition which contributes to giving the beer its characteristics quality. The major cereal that has gained the attention of maltsters and brewers is sorghum. Sorghum is a prominent crop grown in the tropics and subtropical regions of Africa and Asia. It is cheap, locally available and contains about 70% starch which makes it suitable for beer making.

On the other hand, wine is an alcoholic beverage made from fermentation of grape juices [3]. Winemaking is the production of wine, starting with selection of the fruit, its fermentation into alcohol, and bottling of the finished liquor. The science of wine and winemaking is known as oenology. While wine has been made from different fruits through ages, grape has always been the classical and well known fruit to use. The use of other fruits such as pineapple will give products of desired quality and help create variety while reducing the overall cost of grape fruits. Pineapple which is a prominent fruit grown in the tropics can also be used as raw material for winemaking since grape is not grown in the tropics. Pineapples contain good sugar proportion in its fleshy fruit which makes it suitable for wine making [4].

Nowadays, it is observed that there is a significant increase in the consumption of non-alcoholic beverages, probably due to medical/health reasons, religious doctrines, tribal influence and personal perception. Meanwhile producing "alcohol-free" beer or wine with all the organoleptic properties intact will definitely satisfy consumers that are not into consumption of alcoholic beverages. The term 'alcohol-free' beer or wine may be applied to a beverage that contains 0.5 percent alcohol by volume (ABV) or below [5]. Alcohol-free beer or wine starts almost from the full process of beer or wine making up to fermentation. Though the regular beer or wine will then be bottled and aged, the alcohol-free beer or wine has to have its alcohol removed through a process known as dealcoholization.

The success of this research work will create awareness as well as variety in the beverage industry, provide a new frontier in this sector and bridge the gap amongst non-alcoholic beverage consumers if the organoleptic attributes of alcohol-free beverage will impact the same satisfaction as that from alcoholic beverage. Therefore, this research work is aimed at the production and evaluation of alcohol-free beer and wine using a simple distillation technique.

2. MATERIALS AND METHODS

2.1 Source of Materials

Grains of white sorghum variety (*Sorghum bicolor L. moench*) that is less than one year old was purchased from Federal Ministry of Agriculture, Samaru, Zaria, Kaduna State. Hop Pellets, yeast (*Saccharomyces cerevisiae*), and malted barley were obtained from the laboratory of Department of Food Science and Technology, Federal University of Technology, Owerri., Nigeria.

Whole ripe pineapple fruits were purchased from Relief market, Owerri, Imo state, Nigeria. Wine yeast (*Saccharomyces cerevisae*) was supplied by Bioferm Rouge, Beverlo, Belgium.

The processing of samples and experiment were carried out using the facilities available at the laboratory of Department of Food Science and Technology, Federal University of Technology, Owerri, Nigeria.

2.2 Sample Preparation

2.2.1 <u>Production of Sorghum Malt</u>

The sorghum grain was malted using similar malting protocol for barley according to Kunze [6]. Sorted and weighed sorghum grains were steeped in water for 24 hours at a temperature of 20 - 25^{0}C with 6 hours interval of wet steep period and 30 minutes of air rest. The steeped grains were drained and heaped on a jute bags previously sterilized with steam. The grains were kept in a dark and humid environment at a temperature range of 20 - 25^{0}C for germination to take place. The grains were germinated for 2days (48hours) followed by kilning. Kilning was achieved in a hot air oven at temperature of 75 - 80^0C for about 2-3hours. The sorghum malt was continuously turned to aerate and achieve uniform heat distribution. The rootless were removed and cleaned to remove dust and other unwanted particles, and the malted sorghum grains were milled into different particle sizes - Coarse, medium and fine grist using hammer mill.

2.2.2 Production of Pineapple Juice

The pineapple fruits were sorted to remove debris and extraneous materials and washed in a solution of sodium metabisulphite. The whole fresh pineapple fruits were sliced without removing the peel, then macerated and crushed, and followed by juice extraction.

2.3 Mashing of Malted Sorghum and Sparging

The procedure used was the method of Barnes and Zane [7] with slight modification for mashing of the malted grains. The method involves three-step decoction mashing. Two kilogram (2kg) of malted grains were dissolved in eight litres (8L) of portable water that was previously made to a pH of 11.0 using $Ca(OH)_2$ solution. The entire mash temperature was raised to 35-40^0C to acidulate the mash (Acid rest) which was done by direct heating of the entire mash and the temperature maintained for 30 minutes with gentle stirring. One-third of the mash was transferred to a mash kettle and boiled. The boiled mash was transferred back to the remaining two-third mash raising the entire temperature to 50^0C – 55^0C (Protein rest) and allowed to rest for 30 minutes. One-third of the mash was collected again and transferred to the mash kettle where they are boiled for about 10-15 minutes and the boiled mash transferred to the remaining two-third thin mash raising the temperature to about 65-67^oC which was allowed to rest for 15 minutes. Another portion (one-third) of the mash was collected again and transferred to the mash kettle and boiled to 100^0C. The boiled mash was added to the remaining mash, raising the entire temperature to about 72 – 75^0C and the mash was rested again for about 30 minutes for saccharification to occur. Conversion (hydrolysis) of starch in the mash was tested by pipetting 2 drops of iodine solution on a white ceramic tile. Thus, a negative test for starch indicated that all starch molecules have been hydrolyzed to fermentable sugars. The converted medium was filtered across a triple layer muslin cloth and the spent grains were sparged with 1000ml of hot sparge water to obtain the entire wort from the mashing operation.

2.4 Sorghum Beer Production

The method described by Kunze [8] was used for beer production. The recovered wort was boiled for 30-45minutes. Hop extracts were added to the boiling wort so as to impact unique characteristic flavour and herbal aroma to the product. The boiled wort was cooled and the hot trubs and other undissolved particles (debris) were removed in order to ensure flavour and colloidal stability of the beer. The filtered wort was transferred into fermenters (fermenting vessels) and 200ml of already activated yeast culture were pitched into each of the vessel at a temperature of 20^0C and the wort fermentation was carried out at 10^0C – 20^0C for 8 days. After fermentation, the beer was filtered and transferred into another vessel for maturation and analyses were later carried out on the beer.

2.5 Production of Pineapple Wine

The pineapple juice was standardized using granulated sugar in order to bring the brix level to 18.4 ^{o}B. The activated yeast was pitched into the juices and the mixture was transferred into the fermentation vessel and left in a cool place at about 10–18 ℃ for 12 days for fermentation to take place. The resultant pineapple wine were siphoned separately into sterile bottles and corked with a wooden stopper. The products were allowed to mature for a period of 2 weeks and analyses were carried out on the wine.

2.6 Dealcoholization of Sorghum Beer and Pineapple Wine

This was done by using a simple distillation assembly according to the method of Caluwaerts [9]. The alcoholic beverages (Sorghum beer and pineapple wine) were transferred into the distillation flask (pot) and then dealcoholized by ethyl alcohol vaporization at a temperature of 75 - 80^0C until all the ethyl alcohol is vaporized and condensed (in the condenser). Thereafter, the alcohol free beer and wine were bottled and allowed to age.

2.7 Quality Evaluation sorghum beer, pineapple wine and dealcoholized products.

2.7.1 Determination of pH

The pH of sample was determined using A.O.A.C. [10] procedure. The pH meter electrode was thoroughly rinsed with distilled water and reading adjusted to zero mark. The meter was then standardized in buffer 4, 7 and 9 solutions at 25^{o}C. Each 25ml of the sample was pipette into a beaker and the pH electrode (probe) was dipped into the sample and the reading was allowed to stabilize before reading off.

2.7.2 Determination of Brix

The brix of the sample was determined according to the method described by A.O.A.C. [11] using a Milwaukee refractometer. The glass prism of digital refractometer was cleaned with distilled water and blotted with a clean wiper. Few drops of the test sample were placed on the optical (sensitive) region of the refractometer using a micro pipette and the reading was noted from the visual display and thus recorded.

2.7.3 Determination of Specific Gravity of the wine

The method of A.O.A.C [11] was used for the determination of specific gravity of the sample using density bottle as stated below:

Thus,

$$\text{Specific Gravity} = \frac{\text{Density of sample}}{\text{Density of equal volume of water}} \qquad 1$$

2.7.4 Determination of percentage Ethanol

This was determined by distillation technique according to the method described by Onwuka [12].

$$\%\ \text{Ethanol} = \frac{\text{Volume of distillate}}{\text{Volume of sample used}} \times 100 \qquad 2$$

2.7.5 Determination of Total Titratable Acidity

The method of A.O.A.C. [13] was used for the determination of total titratable acidity of the beverage samples.

2.7.6 Determination of Esters and Higher Alcohols

The method of A.O.A.C [14] was used for the determination of esters and higher alcohols of the beverage sample.

2.8 Statistical Analysis

Data obtained from these analyses were subjected to T-test and one-way analysis of variance. Means obtained were separated using Fisher's Least Significant Difference at *P= .05*.

3. RESULTS AND DISCUSSION

3.1 pH: The mean values of pH of pineapple juice, pineapple wine and dealcoholized pineapple wine as well as sorghum wort, sorghum beer and dealcoholized sorghum beer is presented on Table1. Pineapple juice recorded the highest pH value of 3.90 while pineapple wine recorded the least pH value of 2.89. There were significant differences (*P= .05*) amongst the pH values of juice, wine and dealcoholized pineapple wine. On the other hand, sorghum wort recorded the highest pH value of 5.63 while sorghum beer recorded the least pH value of 4.40. There were significant differences (*P= .05*) amongst the pH values of the wort, beer and dealcoholized sorghum beer. The range of pH for pineapple products (2.89 - 3.90) and sorghum malt products (4.40 - 5.63) were in acidic region.

Table 1: Physicochemical Properties of Pineapple and Sorghum Products

PARAMETERS	PINEAPPLE JUICE	PINEAPPLE WINE	DEALCOHOLIZED PINEAPPLE WINE	SORGHUM WORT	SORGHUM BEER	DEALCOHOLIZED SORGHUM BEER
pH	3.90[a]±0.14	2.89[c]±0.09	3.57[b]±0.13	5.63±0.03[a]	4.40 ± 0.14[b]	5.00 ± 0.14[c]
Brix	18.40[a]±0.57	8.00[b]±1.41	6.00[c]±0.71	16.15±0.21[a]	4.70 ±0.14[b]	4.40 ± 0.14[c]
TTA (g/100ml)	0.072[c]±0.01	4.284[a]±0.00	3.60[b]±0.14	0.01± 0.002[b]	0.01±0.001[b]	0.002±0.002[a]
SG	1.0920[a]±0.001	1.0010[c]±0.001	1.0105[b]±0.001	1.07±0.006[a]	1.02±0.001[b]	1.04±0.001[c]
Ethanol (%)	ND	11.87*±1.75	0	ND	6.99*±0.268	0
Higher Alcohols (g/100L)	ND	24.12*±0.17	0	ND	12.38*±0.48	0
Esters (g/100L)	ND	289.13*±0.183	0	ND	231.57*±29.79	0

Values are the means of duplicate determinations

a,b….means with the same superscript along a column for each treatment is not significantly different (P>0.05)

Keys:

TTA = Total Titratable Acidity

SG = Specific Gravity

TSS = Total Soluble Solids

ND = Not Determined

* = Significant mean

The pH values obtained in this research work is comparable to the pH values reported by Liguori *et al*., [15] during dealcoholization of red wine by osmotic dehydration. pH is one of the main quality characteristics that describes the stability of bioactive compounds in food products [16]. Williams and Dennis [17] explained that food products with pH above 5.00 favours microbial activity. It could be observed from the results that the pH of the juice/wort > pH of the dealcoholized wine/beer > pH of the wine/beer. Similar trends were observed for both pineapple and sorghum products. It is possible that higher concentrations of organic acids were produced during fermentation, thus causing a significant reduction (*P*= *.05*) in the pH of wine and beer. However, it could also be observed that the pH of the fermented beverage increased after dealcoholization as a result of the breakdown of volatile organic acids in the wines due to heat from the distillation process [18]. Organic acids can affect pH values dramatically and also have implications on biological stability, sensory properties and the colour of the wine [18].

3.2 Total Titratable Acidity: Pineapple juice recorded the least TTA value of 0.072g/100ml while pineapple wine recorded the highest TTA value of 4.284g/100ml (Table 1). There were significant differences (*P*= *.05*) amongst the titratable acidity of juice, wine and dealcoholized pineapple wine. However, Sorghum wort and sorghum beer recorded the highest TTA content of 0.01g/100ml while dealcoholized sorghum beer recorded the least TTA of 0.002g/100ml. The TTA for dealcoholized pineapple wine (3.60g/100ml) obtained in this work is higher than the total acidity of 0.545g/100ml to 0.573g/100ml of dealcoholized Aglianico wine reported by Liguori *et al.,* [15]. The differences could be as a result of variations in raw materials and the type of alcohol removal method adopted. It could be observed from the results that the TTA of the dealcoholized wine/beer is significantly lower (*P*= *.05*) than the TTA of wine/beer. Similar trends were observed for both pineapple and sorghum products. It is possible that fermentation caused a significant increase (*P*= *.05*) in the TTA of wine, as heat from dealcoholization might have caused a reduction in volatile organic acids. According to Boulton *et al*., [20] increases in titratable acidity can often be attributed to increased concentrations of organic acids especially succinic acid. Succinic acid is a normal by-product of alcoholic fermentation. However, it could also be observed from the results that there was a significant increase in pH and a decrease in TTA after alcohol was removed from both pineapple and sorghum products. Total titratable acidity is a measure of the total amount of hydrogen ions in solution. With this definition, it may seem that a relationship exists between pH and TTA but unfortunately, there is no direct or predictable relationship between pH and TTA. Rather, pH is influenced by the ability organic acids in beverages to dissociate but not correlated to the concentration of organic acids present in the beverage [21].

3.3 Brix: Pineapple juice recorded the highest brix value of 18.40^{o}B while dealcoholized pineapple wine recorded the least brix value of 6.00^{o}B. (Table 1). Also, the highest brix value (16.15^{o}B) was recorded by sorghum wort while dealcoholized sorghum beer had the least brix value of 4.40^{o}B. There were significant differences (*P*= *.05*) amongst the brix values of juice/wort, wine/beer and dealcoholized wine/beer for both pineapple and sorghum product. The variations and significant differences (*P*= *.05*) in the brix value of the juice/wort, wine/beer and dealcoholized wine/beer for either pineapple or sorghum could be attributed to the inherent differences among the processing treatments and soluble extracts after each unit operation. The type and amount of sugars in the beverages and source/variety of raw material can affect the brix measurement as a result of changes in the refractive index of the solution due to the different soluble substances in the solution [22]. From the results, it could be observed that pineapple juice recorded the highest brix content, followed by pineapple wine. It is evident that the yeast strain utilized in fermentation converted almost 56% of sugars in pineapple juice to pineapple wine while 71% of sugars as well as other soluble extracts in sorghum wort was converted to sorghum beer. Fermentation by the action of yeast cells is a metabolic process that consumes sugar in the absence of oxygen to yield organic acids, gases and/or alcohol [23]. On the other hand, the brix content of the pineapple wine was significantly (*P*= *.05*) reduced after alcohol was removed. This could be attributed to distillation of the wines that caused losses of some volatile compounds such as organic acids, fusel oils and esters that contributed to the total dissolved solids in the beverage; since brix measurement is a valuable indication of total soluble solids in a solution for non-sucrose based product.

3.4 Specific Gravity: Pineapple juice recorded the highest SG value of 1.0920 while pineapple wine recorded the least SG value of 1.0010. (Table 1). Furthermore, sorghum wort had the highest SG value of 1.07 while the least SG value (1.02) was recorded for sorghum beer. There were significant differences (*P*= *.05*) amongst the SG values of juice/wort, wine/beer and dealcoholized wine/beer for both pineapple and sorghum products. The variations and significant differences (*P*= *.05*) in the SG value of the pineapple and sorghum products might have been due to principally varying levels of solid contents in the beverages which contributed to its density. The specific gravity of beverages is the density of these products compared to that of water at equal volumes and equal temperature [24]. From the result, it could be observed that pineapple juice and sorghum wort recorded the highest SG while pineapple wine and sorghum beer had the least SG. It is also worthy to note that, pineapple juice and sorghum wort with the highest brix content recorded the highest SG as well. This however, corresponds to the fact that the varying levels of dissolved solids expressed as brix in the juice/wort positively affected the specific gravity of the juice/wort. On the other hand, similar trend was not observed for the specific gravity of pineapple wine and sorghum beer. This could probably be due to the presence of high concentration of alcohol in the wine/beer since alcohol is less dense than water, thus gives a lower SG when compared to water. This could also be observed in the dealcoholized pineapple wines and dealcoholized sorghum beer with specific gravity (1.0105 and 1.04) that are significantly higher ($P= .05$) than the pineapple wine and sorghum beer (1.0010 and 1.02) respectively. The higher SG in dealcoholized wine/beer could be as a result of absence of alcohol, thereby giving room for the varying levels of dissolved solids in the beverage to weigh higher than their corresponding pineapple wine and sorghum beer.

3.5 Ethanol Content: Pineapple wine had an ethanol content of 11.87% (V/V) while the dealcoholized pineapple wine recorded 0% ethanol content. The ethanol content of the pineapple wine in this research work is also comparable to the range of ethanol content of 11.36% to 12.72% reported by Ibegbulem *et al.,* [25]. However, the ethanol content of sorghum beer was recorded as 6.99% while the dealcoholized sorghum beer had an ethanol content of 0%. Ethanol is present in alcoholic beverages as a consequence of the fermentation of carbohydrates with yeast and it's responsible for the beverage's body [26]. The concentration of ethanol in the pineapple wine and sorghum beer could be attributed to the amount of soluble solids or extracts, mostly sugars, in different compositions and concentrations present in the pineapple juice and sorghum wort, as this was also evident in their brix values. According to Jordao *et al.,* [27], the sugar composition of fruit juices or soluble extracts has a key role in wine/beer quality, since they determine the alcohol content of the wine or beer. The 0% ethanol content in the dealcoholized pineapple wine and dealcoholized sorghum beer is an indication that the entire ethanol in the wine or beer samples were completely distilled off as distillate during the distillation process. This research work has demonstrated that it is possible to obtain 100% alcohol free wine by distillation method. In line with this statement, it is important to note that Liguori *et al.,* [15] reported 98.53% reduction in alcohol after Aglianico wine with 13% ethanol content was dealcoholized to 0.19% using osmotic dehydration method. As ethanol is more volatile compared to water, it is logical to remove ethanol from pineapple wine and sorghum beer by heating (distillation). As noted previously, ethanol not only gives off an alcoholic odour and body to beverages, but also acts as a carrier of other odour-active volatile compounds [28]. Ethyl alcohol is the only alcohol generally present in sufficient amount to be of sensory significance in wines. It generates a complex of sensory perceptions as it possesses a distinctive odour, activates the perception of sweetness, and stimulates the sensations of heat and weight in the mouth. Therefore, a complete loss of ethyl alcohol up to 100% as recorded in this research work may affect the sensory perceptions of the dealcoholized wine and beer.

3.6 Higher Alcohols: The higher alcohol content also known as fusel alcohol or fusel oil of pineapple wine was recorded as 24.12g/100L while the higher alcohol content of sorghum beer was recorded as 12.38g/100L. However, the higher alcohol content of dealcoholized pineapple wine and dealcoholized sorghum beer was recorded as 0g/100L for both products. The significant variations in the amount of higher alcohol between pineapple wine and sorghum beer could be as a result of differences in substrates and yeast strains used during fermentation of the beverages. Aside ethanol, higher alcohols are the major alcohols that impart sensory properties to wines. Some of these higher alcohols include but not limited to the following; ethyl ether, 1-propanol, isobutyl alcohol, isoamyl alcohol, 1-hexanol, phenethyl alcohol and pentyldecanol. Higher alcohols impart a range of organoleptic attributes such as alcoholic, fruity, pungent, solvent-like and rose-like or floral, depending on the concentration and type of alcohol [29].The 0g/100L higher alcohol content in the dealcoholized pineapple wine and dealcoholized sorghum beer is an indication that the entire higher alcohol in the wine samples were also completely distilled off as distillate during the distillation process. This is possible because just like ethanol, higher alcohol are also alcohols but with more than two carbon atoms in its molecule. As ethanol is more volatile compared to water, so is fusel alcohol more volatile than water and it is also logical to expect that higher alcohols will be removed from pineapple wine and sorghum beer by heating (distillation) just like ethanol. Higher alcohols are quantitatively major volatile by-products of fermentation and are thought to contribute to the aromatic complexity of wine as well as beer [30].

3.7 Esters: The ester content for pineapple wine was recorded as 289.13g/100L while that of sorghum beer was recorded as 231.57g/100L. However, the ester content of dealcoholized pineapple wine and dealcoholized sorghum beer was recorded as 0g/100L for both products. Moreover, some of these esters include but not limited to the following; ethyl acetate, ethyl hexanoate, ethyl octanoate, ethyl decanoate and phenethyl butanoate. It is important to note that esters and water are formed when alcohols react with carboxylic acids. The esters in pineapple wine and sorghum beer obtained in this research work is relatively higher compared to that reported by Madrera *et al.,* [31]. Often times, high concentrations of esters in alcoholic beverages is an indication of improper and unfavourable fermentation resulting to high acetic acid production, which might react with ethanol and higher alcohols present in the wine to produce higher concentrations of esters.

Esters are however very important compounds due to their particular contribution to flavour and aroma, since they have the lowest organoleptic threshold [32]. The quantity of this compound presented in the final product can vary widely, since it is synthesized from acetic acid and ethanol [33]. They are formed during alcoholic fermentation via yeast metabolism and qualitatively present the major class of flavour compounds in fermented beverages [34]. Ethyl acetate is the major ester present in alcoholic beverages. Esters, generally, are associated with a pleasant, fruity and flowery aroma. Their contribution to flavour is strongly influenced by their concentration [35,36]. From the result, esters were completely removed from both dealcoholized beverages probably because higher alcohol which serves as esters precursors were also completely removed during distillation. Therefore, the complete loss of esters up to 100% as recorded in this research work may also affect the sensory perceptions of the dealcoholized wine and beer since they also contribute to the final sensory attributes of any fermented beverage.

4. CONCLUSION

Dealcoholized wine and beer of 0% (V/V) ethanol was obtained from pineapple wine and sorghum beer through a simple distillation technique. The effect of dealcoholization pineapple wine and sorghum beer is significant for pH, brix, titratable acidity and specific gravity when compared to their corresponding wine and beer respectively. The volatile fraction (higher alcohol and esters) of wine and beer which contributes to the sensory quality of the alcoholic beverages decreased significantly up to 100% at the end of the distillation process. With increasing demand of alcohol-free wines and beers, it opens up opportunity for both scientists and engineers in the field of fermentation or separation processes to make such alcohol-free products available, with comparable taste and flavour to that of regular wines and beers while retaining the beneficial bioactive components inside the wine.

5. RECOMMENDATION

It is recommended that efforts should be placed on the research and development of finding prospective separation processes that may yield products that are both healthy (dealcoholized) and delicious (acceptable sensory and organoleptic aspects). Also, future work should be focused on flavour enrichment, by adding specific aroma compounds or wine/beer volatiles recovered from stripping stream, to make a delicious non-alcoholic beverage from wine/beer.

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