IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Pineapple Wine Fermentation: A Review

[1]Sourabh Pujari,[2]Guruprasad Bhandwale,[3]Raviraj Patil, [4]Shantanu Deshpande

[1,2,3,4]Student, Dept. of Biotechnology Engineering, KIT's College of Engineering, Kolhapur, India

Abstract:Pineapple is one of the largest produced fruits in the world with an annual production of 28.2 million tons, However, considerable of fruit production get spoiled and remain unutilized as post-harvest losses and pineapple is no exception. Pineapple (Ananas comosus) is one of the most popular and the choicest fruit in the world. Wine production from pineapple is a very good alternative to utilize the surplus and value addition. The literature available on pineapple wine production and characterization, the need of fruit wine and pineapple wine production and optimization of conditions has been reviewed briefly. To utilize the surplus for wine production has potential to contribute considerably to postharvest loss reduction and providing value added products.

Index Terms **- Pineapple, wine production, optimization of fermentation conditions**

I. INTRODUCTION

Wine has been with us since the dawn of civilization and has followed humans and agriculture along diverse migration paths [1]. It is regarded as a gift from God and has also been described as a divine fluid in Indian mythology from ancient times. In Rigveda we find mention of wine as oldest fermented product known to man [2]. Wine is referred a completely or partially fermented juice of the grape, also fruits other than grapes, like apple, plum, peach, pear, berries, strawberries, cherries, currants, apricots, pineapple etc., have also been utilized for the production of wines [3]. In earlier days wine is produced by fermenting grape juice with indigenous bacteria called wild yeast present on grape. Presently, the majority of commercial wine yeasts are strains of Saccharomyces cerevisiae because of their superiority of aldehyde production and rate of sugar utilization during fermentation [4].

Fruits are highly perishable and should be consumed immediately or stored in other forms. Many of the fruits are consumed fresh, but large quantities of harvested fruits are wasted during peak harvest periods, due to the high temperature and humidity, poor handling, poor storage facilities and microbial infections. Therefore, winemaking from such ripe fruits or their juices is considered as an alternative of utilizing surplus and over- ripe fruits for generating additional revenues for the fruit growers [3]. In 2019, the global production of fresh fruit amounted to some 883.42 million metric tons and mainly concentrated in Asia. China is leading country in fruit production followed by India, Brazil, usa, Spain and Mexico. In 2019, world production of pineapples was 28.2 million tonnes, led by Costa Rica, the Philippines, Brazil, and Indonesia as the largest producers [48]. There are more than 37 varieties of pineapples grown across the world. Shelf life of pineapple is about 2-3 days making limited availability in fresh market. An alternative and profitable method of winemaking from pineapple is widely acceptable. Many investigators have carried out much research on pineapple composition, and on cultivation aspects and this review will give the detailed up to date knowledge on pineapple wine research.

II. REASON FOR WINE PRODUCTION FROM PINEAPPLE

Fruits both in fresh as well as in processed form not only improve the quality of our diet but also provide essential ingredients like vitamins, minerals, carbohydrates etc [5]. Due to advancement in agriculture field surplus amount of pineapples are produced in world. The excess pineapples (after export) and some unattractive varieties of pineapple need to be utilize. Due to increase in global production of pineapple different end products has remarkably increased the pineapple waste accumulation [6]. A research had reported that pineapple waste which consists of peel, core and unwanted parts of pineapples contain up to 6.14% of carbohydrate, minerals especially magnesium and 0.6% of crude protein [7]. Thewastes from pineapple canneries have been used as the substrate for bromelain, organic acids, ethanol, etc. since these are potential source of sugars, vitamins and growth factors [8, 9, 10, 11].
Wine production from fruits is developing technology. Fruit wines are produced and consumed all over the world. There is wide range of alcoholic beverages produced from fruits and their distillate named brandy.Wine preparation from pineapple and its unutilized parts is considered a developing technology. This not only utilizes surplus fruits but also provides additional income for farmers. Fruit wine has wide range of health benefits on human health. It has been used as therapeutic agent and highly acclaimed for its medicinal or therapeutic value [12, 13]. Pineapple wine is a kind of low-alcohol beverage produced from pineapple. It not only has the characteristic flavor of pineapple fruits,but also maintains the nutrition and health effects of the fruit [14]. Therefore various techniques and technologies are developed for preparing wine from fruits.

III. SELECTION OF PINEAPPLE VARIETY

Pineapples for wine making are generally selected according to juice quality, quantity and physic-chemical characteristics (soluble solids, density, pH, titratable acidity etc). Juice from varieties of pineapples is compared for physical, chemical and sensory characteristics. Cultivars of the Cayenne group have a high content of total soluble sugar and acidity. Queen group pineapple contains high sugar and moderate acidity. Both sugar and acidity are low in Spanish group cultivars. 'Pérola' is one of the most important cultivars of the Pernambuco group, with a higher total soluble sugar and a lower acidity [15]. Some physical psycho chemical and biochemical characteristics of juice of pineapple varieties Red Spanish and Smooth Cayenne have been studied [16]. A study of physico-chemical, microbiological, and organoleptic parameters was used to analyze the quality of the juice of 'abacaxi' variety of pineapple in Benin. This study highlighted potential of the "abicaxi " pineapple variety in wine production [17]. Taking Hainan fresh pineapple as raw materials pineapple wine has been produced [18]. Composition and flavour profile of wine can be alter with variety of pineapple. Thus, selection of good variety is essential for wine making.

.

IV. SCREENING OF YEAST STRAIN

Fruit juice must be inoculated with selected yeast to enhance the quality of wine. In some cases wild yeast also play some role but their contribution is unknown. In pineapple wine fermentation different investigator had used different strains of yeast to examine the efficiency of yeast. Saccharomyces genus is effective yeast in production of alcohol in pineapple juice [19]. S. cerevisiae species isolated from the fermenting sap of Elaesis guineansis (palm wine) was suitable for winemaking from pineapple fruits [20]. Effect of innate micro organism and baker's yeast has been studied [21]. H. uvarum and P. guilliermondii were the main species isolated from the freshly crushed pineapple juice and were used in fermenting of pineapple juice. P. guilliermondii was dominant was dominant in early stage of fermentation whereas H. Uvarum species populations increased at the end of 6 day fermentation. This research also conclude that due to absence of Saccharomyces yeasts in pineapple juice some effects on the other autochthonous yeasts having important role in alcoholic fermentation [22]. Alcoholic fermentation of the pineapple juice with three strains of Saccharomyces cerevisiae (TT, AW, EM2) shows highest ethanol production(more than 8% v/v) in TT and AW and slightly lower (7.60 v/v) in EM2 [23]. The pineapple wines produced by the 4 yeasts were evaluated by sensory in order to select excellent strain for pineapple wine production. The results showed that No.4 yeast (WEIER) grew fast with excellent fermentation performance, and could endure high-alcohol and high-sugar concentration and is good for pineapple juice fermentation [24]. The pineapple juice fermented with single and mixed starter cultures of Saccharomyces cerevisiae, Saccharomycodes ludwigii and Hanseniaspora has been studied [25]. Pineapple wines fermented with successive inoculation of Metschnikowia agaves P3-3 and Saccharomyces cerevisiae D254. The successive inoculation of non-Saccharomyces and Saccharomyces yeasts may be a valuable method to manipulate yeast succession and to modulate the volatile profiles and organoleptic properties of pineapple wine [26]. The effect of four commercial Saccharomyces cerevisiae strains (D254, VIC, BV818 and CECA) on volatile compounds of fermented pineapple (Ananas comosus L. Merr.) juice was investigated. In terms of global aroma, strain D254 that yielded the highest total number and concentration of volatile compounds could be used as a starter culture for the making of intense pineapple wine [27]. The pineapple peel slag as raw material with 4 strains of wine-brewing yeast: CY3079, DV10, K1 and QA23, aroma components of pineapple wine with different yeast strains after primary fermentation were analyzed and compared by using solid phase microextraction and gas chromatography-mass spectrum [28]. The study revealed that varying the amount of yeast concentration had significant effects on the physico-chemical properties, sensory properties of the pineapple wines. 6% v/v yeast concentration is more acceptable and should be adopted in the fermentation of pineapple wine [29].

V. OPTIMIZATION OF PRODUCTION CONDITIONS

The maximum yield of wine rich in flavour and prominent style is obtained when important parameters are optimized. The fermentation technology of pineapple juice was studied and using orthogonal experiment analysis optimum fermentation conditions were determined. The optimum fermentation conditions were: temperature 22 ºC, sugar concentration 240 g/L, inoculums concentration 6 %, SO2 amount 80 mg/L, pectinase amount 120 mg/L. The results showed that is conditions are favourable for pineapple wine with special flavour, colour and high quality [30]. For the production of low alcohol pineapple wine with strain Y19 optimum conditions were determined. The important parameter effecting wine quality are also optimised as temperature 20 oC, sugar content 20%, K2S2O3 concentration 110 mg/L. Using this condition wine was produced with 10% alcohol concentration and 45g/L sugar content [31]. In literature for Optimization of fermentation process condition of pineapple fruit wine, single factor experiments and orthogonal test was used. Optimum conditions were temperature 28 oC, Initial sugar content 18% and yeast inoculums concentration 10% [32].Pineapple wine shows good sensory characterization and chemical properties when fermenting with the conditions of 260 g/L initial sugar, temperature of 20 ˚C, 5 % yeast inoculation. The pineapple wine contains 2.29 g/L total acid, 10.2 % (v/v) alcohol, 5.4 °Brix soluble solids, pH 3.52 [33]. Finally, it can be conclude that optimization of fermentation conditions are very crucial in obtaining best quality wine from mango juice.

VI. CHARACTERIZATION OF PINEAPPLE WINE

The presence of crucial bioactive substances and aroma compounds in pineapple peels indicates abundant evidence. A new kind of wine from pineapple (peel) has been developed. After fermentation produced wine contains 14.71 % vol (v/v) alcohol, the soluble solids only is 7.50°Brix, the content of titratable acid, total flavonoids and phenolic were 3.06 g citric acid/L, 182.76 mg GAE/L and 675.43 mg GAE/L, respectively [34]. A tentative study to estimate the contribution of a specific compound to the aroma of the pineapple wine was made using solid-phase microextraction.[35]. A comparative study of wine from pineapple, baobab, and carrot juice had given the composition of pineapple wine. Findings of study related to pineapple wine are moisture content was 89.0%, ash contents was 0.80%, protein contents 0.70%, crude fat contents 0.50%, carbohydrate content 8.90% vitamin C 43.74 mg/100 g, beta carotene 17 mg/100 ml, alcohol contents 12.0%[36]. Pineapple wine detected 68 kinds of aroma components, including 34 esters, 13 alcohols, 4 acid, 8 alkanes, 4 alkene, 2 aldehyde, 3 others [37]. A quick and easy method HS-SPME combined with GC-MS was used to analyze the aroma compositions of pineapple wine fermented by yeast ADT. The results showed that 24 kinds of esters were detected; Octanoic acid, ethyl ester, acetic acid, 2-phenylethyl ester, 1-Butanol.

Alcohol substances were detected in 8 kinds and phenylethyl alcohol is the main alcohol in the fermentation [38]. Wine from the 'abacaxi' variety of pineapple in Benin has a pH of 3.80 ± 0.6, a titratable acidity of 8.20 ± 0.5%, a sugar content of 13.80 ± 0.5%, a density of 995.00 ± 0 2 and an alcohol content of 3.80 ± 0.4% [39]. Wines obtained with the conventional *Saccharomyces cerevisiae* strain, were analyzed by gas chromatography, and a total of 61 volatile constituents were detected [40].

Table 1:Concentration (µg/L equivalents of 1-heptanol) of free volatile compounds from pineapple wines [40]

Compound	Average content(µg/L)	SD
Esters and acetates		
Methylbutyrate	20	7
Methyl 2-methylbutyrate	51	29
Isobutylacetate	80	23
Ethylbutyrate	149	72
Ethyl 3-methylbutyrate	56	23
Isoamylacetate	1671	501
Octylacetate	16	3
Ethyl hexanoate	680	280
Ethylpyruvate	67	50
Ethyllactate	963	66
Ethyloctanoate	1034	498
Ethyl 3-hydroxyhexanoate	501	54
Ethyldecanoate	2887	156
Diethylsuccinate	2467	53
2-Phenylethyl acetate	913	28
Ethylmyristate	280	9
Diethylmalate	44	10
Ethylpalmitate	921	881
Ethyloleate	865	173
Ethylstearate	193	98
Alcohol		
2-Methyl propanol	2558	1430
1-Butanol	34	11
1-Pentanol	808	115
3-Methyl-1-pentanol	16	2
3-Ethoxy-1-propanol	1885	267
2-Ethyl hexanol	31	26
β-Phenylethyl alcohol	12204	3285
Benzyl alcohol	84	15
2-Phenoxyethanol	20	5
4-Ethylphenol	26	5
Syringol	607	80
Tyrosol	4053	1035
C6 compounds		
1-Hexanol	67	36

Compound	Average content (µg/L)	SD
Terpenes		
Limonene	26	15
Linalool	7	3
Acids		
2-Methylpropanoic	263	52
Butyricacid	320	129
2- and 3-Methylbutanoic (isovaleric)acid	132	3
Hexanoicacid	2608	933
Octanoicacid	5478	1693
Decanoicacid	2082	568
Hexadecanoicacid	725	116
Carbonyl compounds		
2-Pentanone	229	36
3-Hydroxy-2-butanone(acetoin)	223	211
2-Cyclohexenone	31	4
Benzaldehyde	77	10
Sulphur compounds		
Methyl-3-(methylthio)propionate	165	48

Ethyl3-(methylthio)propionate	982	84
3-(Methylthio)-1-propanol (methionol)	977	4
Other compounds		
Ethylbenzene	7	2
Hexadecane	31	2
Caprolactone	194	59
Heptadecane	21	6
Nonalactone	19	3
4-Ethylguiacol	11	1
4-Vinylguaiacol	227	56

VII. ANTIOXIDENTS

A study established that wine of good quality could be produced from pineapple juice. Extent of antioxidant activity is in accordance with the amount of phenolics present in that extract and the pineapple fruit being rich in phenolics may provide a good source of antioxidant[41]. The antioxidant properties showed improved characteristics in the wine compared to the must. [42].

VIII. MINERAL CONTENT

The elemental analysis of pineapple wine was determined by EDXRF. The results areshown in table. According to this table, the amount of phosphorus, chlorine, potassiumand calcium are more present than the other elements. [43].

Table 2: The Elemental Contents of Pineapple Wine Sample Determined by EDXRF Method

No	Mineral	Content (%)
1	Potasium	0.1663
2	Chlorine	0.06154
3	Silicon	0.03500
4	Calcium	0.03124
5	Phosphorus	0.01186
6	Aluminum	0.01095
7	Manganese	0.00285
8	Rubidium	0.00135
9	Zinc	0.00130
10	Iron	0.00010

IX. SENSORIAL EVALUATION OF PINEAPPLE WINE

Pineapple fruit wine belongs to a kind of low alcohol wine, when evaluated with color (30 points), aroma (30 points) and taste (40 points) by a group of 10 experts with relevant experience results indicated that quality and sensory evaluation indicated that it is easy to be accepted by the public [37]. The sensory evaluation results of pineapple wine showed that wine had an acceptable color, clarity, aroma, sweetness, mouth feel, alcohol strength and acidity [44].

X. OTHER FERMENTED PRODUCTS FROM PINEAPPLE JUICE

The production of aromatic frutified wine from mango juice is known as pineapple vermouth. Pineapple vermouth had 7.9% of total soluble solids, 1.23% of total sugars and 0.63% of acidity and also some increased physico-chemical and sensory characteristics and considered as acceptable product [45]. vinegar from pineapple peels prosuced by the use of baker yeast (Saccharomyces cerevisae) as an aerobic degradation of sugar to ethanol and Acetobacter aceti oxidizers ethanol to acetic acid and added value by recycle or conversion of supposed wastes into useful products [46]. there is great potential in pineapple waste to produce bio ethanol because it contatins both cellulosic and non-cellulosic sugars [47]

XI. CONCLUSIONS

Wines made from complete or partial alcoholic fermentation of grape or any other fruit contain ethyl alcohol as essential elements and vitamins, sugars, acids, phenolics etc. Distilled liquors or wine from fruits has stimulatory and healthful properties hence preferable. In some parts of the world it is also used for medicinal purposes. There is ample evidence supporting the health benefits associated with regular and moderate consumption of wine, particularly polyphenol-rich red wine. Pineapple is good source of polyphenols and wine from pineapple also serve as an adjunct to the human diet by increasing the satisfaction and contribute to the relaxation necessary for proper digestion and absorption of food.

Tropical fruits are highly perishable therefore either consumed immediately or stored in other form. Due to advancement in agriculture field large amount of fruits are produced each year. In developing countries due to lack in technologies and proper utilization considerable post harvesting losses are reported and estimated to be 30-40%. Wine making from excess fruits gives additional revenue to farmers and economic upliftment of the farmers. And also generates employment opportunities in wine and

allied industries. So production of fruit wines in those countries where fruits other than grape are grown would certainly be advantageous. In future it is necessary to conduct studies on fruit wine on more varieties of pineapple in the world

REFERENCES

[1] Chambers, Paul J., and Isak S. Pretorius. "Fermenting knowledge: the history of winemaking, science and yeast research." EMBO reports 11.12 (2010): 914-920.

[2] Bose, Dhirendra Krishna. Wine in ancient India. Edizioni Savine, 2016.

[3] Jagtap, Umesh B., and Vishwas A. Bapat. "Wines from fruits other than grapes: Current status and future prospectus." Food Bioscience 9 (2015): 80-96.

[4] Joshi, V. K., and Devender Attri. "Panorma of research and development of wines in India." (2005).

[5] Swami, Shrikant Baslingappa, N. J. Thakor, and A. D. Divate. "Fruit wine production: a review." Journal of Food Research and Technology 2.3 (2014): 93-100.

[6] Deliza, R., et al. "Utilization of pineapple waste from juice processing industries: Benefits perceived by consumers." Journal of Food Engineering 67.1-2 (2005): 241-246.

[7] Rosma, A., et al. "Optimization of single cell protein production by Candida utilis using juice extracted from pineapple waste through response surface methodology." Malaysian Journal of Microbiology 1.1 (2005): 18-24.

[8] Larrauri, José A., Pilar Rupérez, and Fulgencio Saura Calixto. "Pineapple shell as a source of dietary fiber with associated polyphenols." Journal of Agricultural and Food Chemistry 45.10 (1997): 4028-4031.

[9] Nigam, J. N. "Continuous ethanol production from pineapple cannery waste." Journal of Biotechnology 72.3 (1999): 197-202.

[10] Nigam, J. N. "Continuous cultivation of the yeast Candida utilis at different dilution rates on pineapple cannery effluent." World Journal of Microbiology and Biotechnology 15.1 (1999): 115-117.

[11] Dacera, Dominica Del Mundo, Sandhya Babel, and Preeda Parkpian. "Potential for land application of contaminated sewage sludge treated with fermented liquid from pineapple wastes." Journal of hazardous materials 167.1-3 (2009): 866-872.

[12] Joshi, V. K., et al. "Science and technology of fruit wines: an overview." Science and technology of fruit wine production (2017): 1-72.

[13] German, J. Bruce, and Rosemary L. Walzem. "The health benefits of wine." Annual review of nutrition 20.1 (2000): 561-593.

[14] CAI, Kun, Mei ZHOU, and Xue LIN. "Research Progress on Fermentation Technology and Aroma Components of Pineapple Wine." Chinese Journal of Tropical Crops (2018): 06.

[15] Sun, Guang-Ming, et al. "Nutritional composition of pineapple (Ananas comosus (L.) Merr.)." Nutritional composition of fruit cultivars. Academic Press, 2016. 609-637.

[16] Bartolomé, Ana P., Pilar Rupérez, and Carmen Fúster. "Pineapple fruit: morphological characteristics, chemical composition and sensory analysis of Red Spanish and Smooth Cayenne cultivars." Food Chemistry 53.1 (1995): 75-79.

[17] AHOUSSI, Léon Akanni, et al. "Valorization of pineapple produced in Benin: Production and evaluation of wine quality parameters." International Journal 3.11 (2015): 830-840.

[18] Jinhai, Zhao, and Wu Yurong. "Development of sparkling wine pineapple [J]." Academic Periodical of Farm Products Processing 11 (2010): 024.

[19] Gardner, E. T., O. I. Enabulele, and K. O. Ajerio. "Studies on the microbiology and production of pineapple (Ananas comosus) wine." Microbios 59.239 (1989): 85-92.

[20] Ayogu, T. E. "Evaluation of the performance of a yeast isolate from Nigerian palm wine in wine production from pineapple fruits." Bioresource technology 69.2 (1999): 189-190.

[21] Emmanuel, Okiemute. "Studies of wine produced from pineapple (Ananas comosus)." International Journal of Biotechnology and Molecular Biology Research 3.1 (2012): 1-7.

[22] Chanprasartsuk, On-ong, et al. "Autochthonous yeasts associated with mature pineapple fruits, freshly crushed juice and their ferments; and the chemical changes during natural fermentation." Bioresource Technology 101.19 (2010): 7500-7509.

[23] Roda, Arianna, et al. "Pineapple wines obtained from saccharification of its waste with three strains of Saccharomyces cerevisiae." Journal of Food Processing and Preservation 41.5 (2017): e13111.

[24] XIAN, Jiawen, Hui WU, and Dongmei LIU. "Screening of brewing yeasts for pineapple wine [J]." China Brewing 1 (2009).

[25] Chanprasartsuk, O., K. Pheanudomkitlert, and D. Toonwai. "Pineapple wine fermentation with yeasts isolated from fruit as single and mixed starter cultures." Asian Journal of Food and Agro-Industry 5.2 (2012): 104-111.

[26] Jia, Yanyan, et al. "Effects of Successive Inoculation of Non-Saccharomyces Yeast on Aroma Components of Pineapple Wine by Mixed-Culture Fermentation." Food Science 17 (2015): 152-157.

[27] Lin, Xue, et al. "Evaluation of different Saccharomyces cerevisiae strains on the profile of volatile compounds in pineapple wine." Journal of food science and technology 55.10 (2018): 4119-4130.

[28] JOURNAL OF FOOD ENGINEERING AND TECHNOLOGY Volume 6, Number 2, December 2017

[29] Udeagha, E. C., et al. "Effects of Yeast Concentration and Total Soluble Solids on the Quality of Wine Produced from Pineapple."

[30] Li, T., and W. Zhong. "Optimization of Fermentation Conditions of Pineapple Wine." Modern Food Science and Technology 27.9 (2011): 1123-1126.

[31] Zhao-jian, G. A. O. "Study on brewing technology of low-alcohol pineapple wine [J]." China Brewing 11 (2005).

[32] LUO, Hui-bo, et al. "Optimization of Fermentation Process Condition of Pineapple Fruit Wine." 食品与发酵科技 3 (2012).

[33] Qi, Ningli, et al. "Production and quality evaluation of pineapple fruit wine." *IOP Conference Series: Earth and Environmental Science*. Vol. 100. No. 1. IOP Publishing, 2017.
[34] Zhang, Li, et al. "Physicochemical characterization of pineapple peel wine." *IOP Conference Series: Earth and Environmental Science*. Vol. 546. No. 4. IOP Publishing, 2020.
[35] Pino, Jorge A., and Oscar Queris. "Analysis of volatile compounds of pineapple wine using solid-phase microextraction techniques." *Food Chemistry* 122.4 (2010): 1241-1246.
[36] Akubor, Peter Isah. "Characterization of fruit wines from baobab (Adansonia digitata), pineapple (Ananas sativus) and carrot (Daucus carota) tropical fruits." *Asian Journal of Biotechnology and Bioresource Technology* (2017): 1-10.
[37] Qi, Ningli, et al. "Production and quality evaluation of pineapple fruit wine." *IOP Conference Series: Earth and Environmental Science*. Vol. 100. No. 1. IOP Publishing, 2017.
[38] Jiang, Y. C., et al. "Changes of aroma components of pineapple wine during fermentation with ADT strain." *IOP Conference Series: Materials Science and Engineering*. Vol. 392. No. 5. IOP Publishing, 2018.
[39] AHOUSSI, Léon Akanni, et al. "Valorization of pineapple produced in Benin: Production and evaluation of wine quality parameters." *International Journal* 3.11 (2015): 830-840.
[40] Dellacassa, Eduardo, et al. "Pineapple (Ananas comosus L. Merr.) wine production in Angola: Characterisation of volatile aroma compounds and yeast native flora." *International Journal of Food Microbiology* 241 (2017): 161-167.
[41] Hossain, M. Amzad, and SM Mizanur Rahman. "Total phenolics, flavonoids and antioxidant activity of tropical fruit pineapple." *Food Research International* 44.3 (2011): 672-676.
[42] Ukeyima, M. T., B. O. Idoko, and L. O. Moghalu. "Antioxidant, Mineral and Microbiological Properties of Wine from Blends of Roselle Calyces Extract and Pineapple Juice." *European Journal of Nutrition & Food Safety* (2020): 49-57.
[43] Myint, Aye Aye, Aye Aye Khaing, and Tu Tu Wai. "Study of Ageing and Production of Wine from Pineapple by Fermentation Process."
[44] Balamaze, Joseph, and J. Wambete. "Production of good quality wine from single and mixture of fruit peels." *African Journal of Food, Agriculture, Nutrition and Development* 17.1 (2017): 11822-11831.
[45] Assumi, S. Ruth, et al. "Physico-chemical characteristics and sensory quality of pineapple vermouth." *Indian Journal of Horticulture* 71.3 (2014): 402-407.
[46] Raji, Yusuf O., et al. "Production of vinegar from pineapple peel." *International journal of advanced scientific research and technology* 3.2 (2012): 656-666.
[47] Tropea, Alessia, et al. "Bioethanol production from pineapple wastes." *Journal of Food Research* 3.4 (2014): 60.
[48] http://www.fao.org/faostat/en/#data/QC (link 1)