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Research Article
Traditional Processing and Quality Assessment of a Fermented Date-Based Beverage Made from Northern Chad

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Abstract

Background and Objective: In the northern part of Chad, dried dates are used in the production of a traditional drink highly cherished by the population. Despite the importance of this beverage, the processing, microbiological and physicochemical qualities remain unknown. To fill these gaps, this study aimed to describe the main stages of the manufacturing process of this beverage and elucidate some of its physicochemical and microbiological properties. **Materials and Methods:** To elucidate the traditional processing of the date beverage, ethnographic techniques were involved. Physicochemical, phytochemical, antioxidant and microbiological parameters were evaluated in ready-to-serve fermented drink samples according to referenced methods. **Results:** It emerged from the field surveys that the production is still rudimentary with an alcoholic fermentation stage using the exogenous starter. Physicochemical revealed that an average pH (3.60±0.01), alcohol (8.7±0.01 g L^{-1}), soluble solids (2.1±0.01°Brix), total sugar (0.007±0.01 g L^{-1}), conductivity (2207±6.4 µS cm^{-1}) and proteins (0.094±0 g L^{-1}) were registered. Microbiology analysis indicated a very good hygienic quality of this beverage with undetectable microbial counts. Moreover, total polyphenols, flavonoids and tannins contents of 3.24±0.15 gGAE L^{-1}, 0.07±0 gQE L^{-1} and 0.08±0 gCE L^{-1} were recorded, respectively. Likewise, both scavenging activity and reducing ferric power of 0.08±0 g Trolox eq L^{-1} and 0.31±0.03 g Trolox eq L^{-1} were registered, respectively. **Conclusion:** These results suggested this fermented date beverage could be a good nutrient source and health benefit for consumers.

Key words: Indigenous beverages, date palm, processing, physicochemical, bioactive property, safety

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Hunger and malnutrition remain a challenge in the world and affect more than 800 M people and 90% of this population is in developing countries[1]. The fight against food insecurity involves, an increase in food production, reducing post-harvest losses and enhancing the consumption and transformation of local products and enhancement of local products by creating by-products that are essential for local consumption[2]. Fermentation is being used by man for the past millennium to transform, preserve or improve the nutritional quality of foods[3]. In many African countries, fruits such as dates, grapefruit and ginger are often transformed into beverages. In the manufacturing process of these fruits, alcoholic fermentation occupied a key place[4]. *Phoenix dactylifera*, also known as date or date palm, is a plant species in the Arecaceae palm family that is grown for its edible sweet fruit[5]. The plant is widely cultivated in many tropical and subtropical regions around the world[6]. Dates (*Phoenix dactylifera* L.) are grown in over 2000 different varieties around the world. The proximate composition of date fruit varies primarily depending on the cultivar, maturation stage, postharvest and growing conditions and so on[7]. The main component of the date fruit is carbohydrate (sucrose, glucose and fructose), which can account for more than 70% of the dry weight and provides net gross energy ranging from 352-425 kcal/100 g. Date fruit is also high in fibre and contains a variety of vitamins and minerals, including iron, calcium and magnesium[8]. The powerful antioxidant, anti-inflammatory, hepatoprotective and anticancer activity of various dates and their derivatives have been documented by many authors[9,10].

In the northern part of Chad, dates are processed into a traditional alcoholic beverage called "siko" from the distillation of the fermented must. The knowledge on the existence of this fermented must as the beverage is not well known in Chad nor bordering countries as Cameroon. Even if, it is sometimes consumed by the local population during popular ceremonies such as marriage, baptism, cultural festivals, burials and funerals. Like most indigenous drinks, this fermented date-based beverage plays an important socio-cultural and economic role and likewise as a refreshing drink for guests. Even if the final product named "siko" is highly consumed by the population, it remains a poor drink in terms of nutritional values and is rich in alcohol but the wort used in the production of "siko" has nutritional values and health benefits attributed to its laxative, antimalarial and anti-hemorrhoidal properties[11]. However, despite the potential gains of this fermented drink made from date quality attributes of this beverage are still uncovered.

So far, there exist no relevant data recorded on the processing of this beverage. Therefore, this study aimed to describe the traditional processing of the fermented date beverage and evaluate its quality attributes.

MATERIALS AND METHODS

Plant material: The plant material used in this study was Deglet-Nour dates purchased in August, 2020 from Maroua central market in the Far North Region of Cameroon. They were placed in sterile packaging bags and transported to the laboratory of Food Science and Microbiology of the Regional Institute of Agricultural and Rural Development (IRAD) of Maroua for identification and treatments. The plant material was identified by botanical experts of the Biological Sciences Department, Faculty of Science, University of Maroua.

Ferment: A commercially purchased brand of yeast (*Saccharomyces cerevisiae*) was used as the lone ferment.

Collection of data on the processing of date fruits: A census was carried out to identify the different production sites in the North of Chad. Abéché and Wadi Dja did were identified as the main production sites. A survey was conducted during May, 2020 in the aforementioned sites. Semi-structured questionnaires assisted with interviewing were adopted to collect information related to the processing strategy of date fruits as reported in Fig. 1. A total of 35 producers and retailers were interviewed during the survey. The process has been described as follow. The sorted dates are washed with clean water, dried, manually pitted, grind using a mechanical blender and sieved using a sieve mesh (1.15 mm in diameter) to obtain a homogenous dried date powder. Two hundred and 50 g of dates flour are mixed with 2.5 L of clean water and the mixture is stirred and boiled for 45 min to obtain a homogeneous preparation. After that, the mixture is transferred into a clean container and cooled at room temperature. After this step, the granulated sugar at a ratio of 1:50 (mv^{-1}) is added, stirred and filtered through a clean cotton muslin to obtain the date must. To initiate the process of alcoholic fermentation, the filtrate is inoculated with hydrated yeast (*Saccharomyces cerevisiae*). Twenty grams of re-hydrated yeasts are inoculated per litre of must. The resulting mixture is left for fermenting for 24 hrs at room temperature. After filtration, the concoction is either ready-to-serve or further distilled for obtaining a strong alcoholic "siko" beverage.

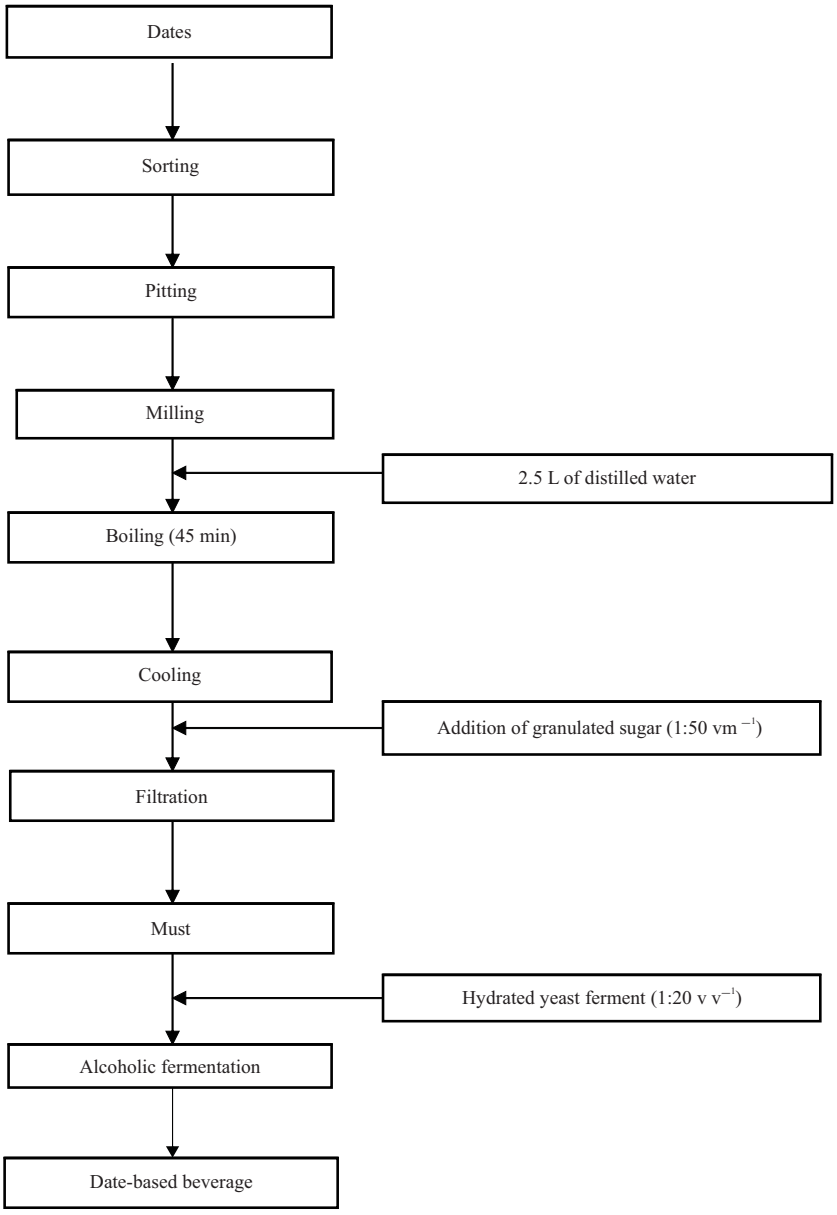

Fig. 1: Flowchart of the traditional processing of the date beverage

Physicochemical and proximate analysis: The pH (Equip-Tronic EQ-610 type), total soluble solids and conductivity (Eco Testr) were measured directly using calibrated portal devices[12]. The titratable acidity was according to the method described by Bayoï *et al.*[13] using 0.1 N sodium hydroxide solution and bromothymol blue as an indicator. Similarly, the total sugar and total proteins contents were assessed spectrophotometrically according to the methods described by Başkan *et al.*[14] and Chang and Zhang[15], respectively. The alcohol content was determined according to the method described by Talebi *et al.*[16].

Microbiological analysis: The hygienic quality of the fermented date must drink was evaluated. The pouring technique of a serially diluted sample was used. The total plate count, spore-forming bacteria and total coliforms were assessed according to standards and referenced methods in specific solid culture media. Plate count agar supplemented with 0.5% cycloheximide, brilliant green agar and glucose bromocresol purple agar were used for total plate count, total coliforms and spore-forming bacteria, respectively. Before seeding, the serial dilutions intended to enumerate spore-forming bacteria were heat-activated at 80°C for 10 min[13]. All

the inoculated plates were incubated at 35°C for 24-48 hrs[17,18]. After that, only dishes having enumerated colonies from 30 and 300 were taken into account[19].

Phytochemical and antioxidant assays: The quantification of phytochemical contents and antioxidant properties of the indigenous fermented date beverage was performed spectrophotometrically. The total polyphenol content was determined using the Folin-Ciocalteu method as described by Khoddami *et al.*[20], total flavonoids contents according to the aluminium trichloride[21] and tannins were assessed according to the protocol of Jørgensen *et al.*[22]. Meanwhile, ferric reducing antioxidant power (FRAP) and DPPH scavenging activity were evaluated using the methods previously described by Hajimahmoodi *et al.*[23] and Sun *et al.*[24], respectively.

Statistical analysis: All the analysis were performed in triplicate. The obtained results were arranged using Microsoft Office/Excel, 2013 for Windows and statistically analyzed with STATGRAPHICS Centurion 16.1 software. The results were presented as Mean±Standard Deviation.

RESULTS AND DISCUSSION

Traditional processing of the fermented date: To produce a functional date-based beverage, the results from the survey led to the elaboration of a modified processing scheme of fermented date must as previously summarised in Fig. 1. From the information gathered during the survey, the processing procedure can be grouped into two classical stages: Brewing and alcoholic fermentation. These classical stages remain the key determining factors in the processing of beverages[25,26]. The use of exogenous ferment is the key determining factor in the fermentation process of date must likewise a wine produced from grapefruits, "tea lémi" is based on spontaneous fermentation[27]. These differences could be related to the nature of the raw material and more so, the action of heat used during boiling to obtain data just might be the prime factor. Because the heat treatment inactivates most of the microorganisms. It exists a great similarity in the traditional processing of fermented date must with some commonly processed beverages like "red kapsiki" beer[12] but dissimilarities remain obvious with other crafted beverages such as "amgba"[27] and "tea lémi" wine[28].

Physicochemical property of the fermented beverage from the date palm fruit: Table 1 showed the physicochemical profile of the indigenous fermented date beverage. The results showed that the drink has an acidic pH (mean pH 3.60). This acidity is most likely linked to the presence of organic acids such as tartaric acid, malic acid and citric acid. This pH value (3.60) is close to that obtained by Marszałek *et al.*[29] on strawberry juice (pH 3.89). In addition, it is less acidic than "red kapsiki" beer (pH 2.79) produced from sorghum in Far North Cameroon[12]. Moreover, according to Alzagtat and Eledody[30], drinks with a pH lower than 4.5 share a satisfactory quality hence, fermented date beverages. The total titratable acidity is relatively low with an average of 0.56 g L^{-1}. The very low titratable acidity level demonstrates an almost total absence of acetification[31]. These results are slightly similar to those obtained with Tunisian date drinks[32]. The average sugar content of the date concoction was 0.007 g L^{-1}. This value was close to that obtained by Al-Mohammadi *et al.*[33] on Kombucha fermented beverage. The alcohol content, which average of 8.7 g L^{-1}, was relatively high due to the hydrolysis of fermentable sugars by microorganisms. The drink had a higher alcohol content than that of Pito (3.09 g L^{-1}) and Tchapalo (5.22 g L^{-1}), two sorghum-based drinks brewed in Nigeria[34] and Ivory Coast[35], respectively. The average total protein content (0.094 g L^{-1}) of the drink is relatively low compared to that found in tchapalo (2.9 g L^{-1}) by Aka *et al.*[26]. This low content could be due to the heating treatment used during the processing, able to denature proteins or microorganisms producing protease responsible for protein hydrolysis. Finally, the samples of the fermented date beverage had an average conductivity of 2207 µS cm^{-1}. The conductivity is a parameter that makes it possible to evaluate the electrolyte content of the drink like in the case of certain mineral ions such as Ca^{2+} and Fe^{2+}. Therefore, in line with the relative importance of this parameter, it would be quite possible that the fermented drink is rich in electrolytes essential for the proper functioning of the body. Indeed, it has been proven that African craft fermented drinks are sources of minerals such as iron, manganese, magnesium, phosphorus, calcium, potassium and copper[36]. However, the values observed can have a noticeable impact on the hygienic level.

Microbiological quality of the fermented date beverage: Table 2 displays the hygienic quality of the date beverage. The total aerobic plate count, total coliforms and total spore-forming bacteria were not detected in the fermented date beverage. Their absence in the drink could be related to the acidic pH coupled to the high content of the beverage, which might not promote the proliferation of certain microorganisms[37]. According to Al-Mohammadi *et al.*[33], high

Table 1: Physicochemical profile of fermented date

Parameters	Mean values
pH	3.60±0.01
Total acidity (g L^{-1})	0.56±0.01
Soluble solids (°B)	2.1±0.01
Total sugars (g L^{-1})	0.007±0.01
Conductivity (µS cm^{-1})	2207±6.40
Total proteins content (g L^{-1})	0.094±0.01
Alcohol content (g L^{-1})	8.7±0.01

Table 2: Microbial quality of the traditional fermented date beverage

Flora	Total count	Total coliforms	Mesophilic spore-forming bacteria
Values	ND	ND	ND
Standards	$<10^6$	$<10^3$	$<10^4$

ND: No detected

Table 3: Phytochemical profile and antioxidant activity of fermented date must

Parameters	Average values
Total polyphenols (g Gallic acid Eq L^{-1})	3.24±0.15
Flavonoids (g Quercetin Eq L^{-1})	0.07±0.01
Tannins (g Catechin Eq L^{-1})	0.08±0.01
FRAP (g Trolox Eq L^{-1})	0.31±0.03
DPPH (g Trolox Eq L^{-1})	0.08±0.01

concentrations of alcohol could inhibit the growth of microorganisms. Therefore think that it is the combined action of the acidity of the medium and the alcohol produced during fermentation that would probably have influenced the growth of microorganisms. The sugar present in the drink under the action of yeast is transformed over time into ethanol. Although ethanol forms the essential metabolite of yeasts, at high concentrations, it may exert an inhibitory effect. The study carried out by Stringini *et al.*[38] on palm wine also showed that the acidic and alcoholic environment cannot be favourable for the microorganisms' growth. In addition, their absence would also be due to the thermal action of boiling and the control of certain crucial operations during the production of the drink. The microbiological analysis showed counts clearly below the requested standards which recommend values lower than 10^6 CFU mL^{-1} for the total aerobic plate count, 10^3 CFU mL^{-1} for total coliform and 10^4 CFU mL^{-1} for the mesophilic total spore-forming bacteria. Generally, the date beverage is of better hygienic quality compared to other traditional drinks like Tchapalo[26], "white kapsiki" beer[13] and "red kapsiki" beer[12]. The good microbial quality of the traditional date beverage could be also associated with the good quality of raw material and water used as well as the good mastering of the production chain of the beverage by the producers.

Bioactive properties of the indigenous fermented date beverage: The phytochemical profile of the fermented date drink is summarised in Table 3. It emerges from the results that the fermented date drink was by far richer in polyphenols (3.24 gGAE L^{-1}) than flavonoids (0.07 gQE L^{-1}) and tannins (0.08 g CE L^{-1}). The polyphenol content of the fermented concoction was higher than those found by Marszałek *et al.*[29] on strawberry juice (2.97 g L^{-1}), Ronald and Roger[12] on sorghum "red kapsiki" beer which had a content that varied from 0.843-1.150 g L^{-1}. The total flavonoid content of the drink was lower than that of "red" sorghum beer, which varies between 0.75-1.3g L^{-1} [12]. The difference observed between these values with no doubt would be linked to the nature of the raw material used for the preparation of these drinks[39]. In addition, Table 3 also showed that the drink had a scavenging activity of 0.08 g Trolox eq L^{-1} and reducing the power of 0.31 g Trolox eq L^{-1}. The scavenging activity of the drink depends on the total polyphenols content meanwhile the reducing power of the drink is a function of total flavonoids and tannins contents. A previous study carried out by Dongdem *et al.*[40] demonstrated a close relationship between the polyphenol content of a drink and its antioxidant capacity expressed from DPPH scavenging activity. This scavenging activity of the drink (0.08 g L^{-1}) was lower than that found by Marszałek *et al.*[29] on strawberry juice (0.51 g L^{-1}) and Al-Mohammadi *et al.*[33] on Kombucha fermented beverage.

CONCLUSION

In conclusion, this study showed that the processing of fermented date-based beverages is tremendous even though some stages remain empirical and rudimentary. The characterization of this concoction revealed satisfactory physicochemical and phytochemical properties displayed by a very low pH and relevant polyphenol content. Similarly, the date beverage was of good hygienic quality due to undetectable counts of total aerobic plate count, total coliforms and total spore-forming bacteria. These appreciable qualities may indicate the mastering of the processing procedure by producers. Despite that, it would be interesting to carry out further technological studies to upgrade empirical stages of the processing and additional microbial analysis to achieve a large view of the hygienic and sanitary qualities of this indigenous fermented date beverage. Moreover, subsequent studies need to be done to assess change during fermentation to get relevant data necessary to improve the quality of this culturally embedded beverage.

SIGNIFICANCE STATEMENT

This study elucidated the traditional processing and microbial as well as antioxidant properties of the fermented

date beverage that can be useful for consumers' nutrition and health. This study will help the researchers to uncover the critical areas of data processing on large scale as well as indigenous processing of local raw materials that many researchers were not able to explore.

REFERENCES

1. Ville, A.S., J.Y.T. Po, A. Sen, A. Bui and H. Melgar-Quiñonez, 2019. Food security and the food insecurity experience scale (FIES): Ensuring progress by 2030. Food Sec., 11: 483-491.
2. Dahouenon-Ahoussi, E., R.G. Degnon, E.S. Adjou, D.C.K. Sohounhloue, 2012. Stabilization of beer produced with amylaceous local raw materials (*Sorghum bicolor* and *Musa acuminate*) by using essential oil from *Cymbopogon citratus*. J. Appl. Biosci., 51: 3596-3607.
3. Gotcheva, V., S.S. Pandiella, A. Angelov, Z. Roshkova and C. Webb, 2001. Monitoring the fermentation of the Bulgarian beverage boza. Int. J. Food Sci. Technol., 36: 129-134.
4. Naumova, E.S., I.V. Korshunova, L. Jespersen and G.I. Naumov, 2003. Molecular genetic identification of *Saccharomyces* sensu stricto strains from African sorghum beer. Fed. Eur. Microbiol. Soc. Yeast Res., 3: 177-184.
5. Mukherjee, A., M. Sharma, S. Latkar and P. Maurya, 2018. A study on heavy metal content in dates available in domestic market in India. Int. J. Chem. Pharm. Anal., Vol. 6. 10.2127 6/ijcpa.
6. Oni, S.O., A.M. Adeosun, O.A. Ladokun, O.M. Ighodaro and O.M. Oyedele, 2015. Nutritional and phytochemical profile of Niger cultivated date palm (*Phoenix dactilyfera* L). J. Food Nutr. Sci., 3: 114-118.
7. Chandrasekaran, M. and A.H. Bahkali, 2013. Valorization of date palm (*Phoenix dactylifera*) fruit processing by-products and wastes using bioprocess technology-Review. Saudi J. Biol. Sci., 20: 105-120.
8. Nadir, A., N.M. Abdelmagauid, I.M.F. Helmy and R.K. Moawad, 2017. Physio-chemical and quality characteristics for date juice at khalal stage. Asian J. Sci. Res., 10: 308-315.
9. Laouini, S.E., L. Segni, M.R. Ouahrani, N. Gherraf and S. Mokni, 2012. Phytochemical analysis, antioxidant and antimicrobial activities of leaves extract of date palm grown in Algeria. J. Fundam. Appl. Sci., 4: 142-154.
10. Atta, H., K. Abo-El-Sooud, S.S. Ahmed, S. Ibrahim and S. Zaher, 2015. Synergistic hepatoprotective effect of grape juice with date palm fruit methanolic extracts. Wulfenia, J., 22: 282-297.
11. Zhang, C.R., S.A. Aldosari, P.S.P.V. Vidyasagar, P. Shukla and M.G. Nair, 2017. Health-benefits of date fruits produced in Saudi Arabia based on *in vitro* antioxidant, anti-inflammatory and human tumor cell proliferation inhibitory assays. J. Saudi Soc. Agric. Sci., 16: 287-293.
12. Ronald, B.J. and D.D. Roger, 2017. Traditional Processing and Quality Control of the "Red Kapsiki": A Local Sorghum Beer from Northern Cameroon. In: Brewing Technology, Kanauchi, M. (Ed.), IntechOpen., London, UK, ISBN: 978-953-51-3342-1, pp: 159-175.
13. bayoï, J.R., R.D. Djoulde and F.X. Etoa, 2016. Manufacturing technology, physico-chemical and microbiological properties of "white kapsiki" beer produced in the Mandara mountains in Northern Cameroon. Afr. Sci. Int. J. Sci. Technol., Vol. 12.
14. Başkan, K.S., E. Tütem, E. Akyüz, S. Özen and R. Apak, 2016. Spectrophotometric total reducing sugars assay based on cupric reduction. Talanta, 147: 162-168.
15. Chang, S.K.C. and Y. Zhang, 2017. Protein Analysis. In: Food Analysis, Nielsen, S.S. (Ed.), Springer International Publishing, New York, ISBN: 978-3-319-45776-5, pp: 315-331.
16. Talebi, M., L.A. Frink, R.A. Patil and D.W. Armstrong, 2017. Examination of the varied and changing ethanol content of commercial Kombucha products. Food Anal. Methods, 10: 4062-4067.
17. da Silva, N., M.H. Taniwaki, V.C.A. Junqueira, N. Silveira, M.M. Okazaki and R.A.R. Gomes, 2018. Microbiological Examination Methods of Food and Water: A Laboratory Manual. 2nd Edn., CRC Press, Boca Raton, Florida, USA, ISBN-13: 9781138057111, Pages: 564.
18. Clarke, R., D. Peyton, M.G. Healy, O. Fenton and E. Cummins, 2017. A quantitative microbial risk assessment model for total coliforms and *E. coli* in surface runoff following application of biosolids to grassland. Environ. Pollut., 224: 739-750.
19. Nemo, R. and K. Bacha, 2020. Microbial, physicochemical and proximate analysis of selected Ethiopian traditional fermented beverages. LWT, Vol. 131. 10.1016/j.lwt.2020. 109713.
20. Khoddami, A., M.A. Wilkes and T.H. Roberts, 2013. Techniques for analysis of plant phenolic compounds. Molecules, 18: 2328-2375.
21. Torija, M.J., G. Beltran, M. Novo, M. Poblet, N. Rozès, A. Mas and J.M. Guillamón, 2003. Effect of organic acids and nitrogen source on alcoholic fermentation: Study of their buffering capacity. J. Agric. Food Chem., 51: 916-922.
22. Jørgensen, M.R., C. Kragelund, P.Ø. Jensen, M.K. Keller and S. Twetman, 2017. Probiotic *Lactobacillus reuteri* has antifungal effects on oral *Candida* species *in vitro*. J. Oral Microbiol., Vol. 9. 10.1080/20002297.2016.1274582.
23. Hajimahmoodi, M., M. Hanifeh, M.R. Oveisi, N. Sadeghi and B. Jannat, 2008. Determination of total antioxidant capacity of green teas by the ferric reducing/antioxidant power assay. J. Environ. Health Sci. Eng., 5: 167-172.
24. Sun, T., J. Tang and J.R. Powers, 2005. Effect of pectolytic enzyme preparations on the phenolic composition and antioxidant activity of asparagus juice. J. Agric. Food Chem., 53: 42-48.

25. Attchelouwa, C.K., S. Aka-Gbézo, F. N'guessan, C. Kouakou and M. Djè, 2017. Biochemical and microbiological changes during the Ivorian sorghum beer deterioration at different storage temperatures. Beverages, Vol. 3. 10.3390/beverages3030043.
26. Aka, S., N.D.T. Djeni, K.F.N. Guessan, K.C. Yao and K.M. Dje, 2008. Variability of the physico-chemical properties and enumeration of the fermentation flora of tchapalo, a traditional sorghum beer in Côte d'Ivoire. Afr. Sci.: Int. J. Sci. Technol., 4: 274-286.
27. Roger, D.D., L. Venassius, E.N.J. Justin and E.F. Xavier, 2013. Processing of "Amgba": A sorghum-maize based beer, brewed in Cameroon. J. Brewing Distilling, 4: 11-18.
28. Bayoï, J.R., Y. Vandi, B.Y. Foundikou and F.X. Etoa, 2021. Traditional processing, physicochemical property, phytochemical content, and microbiological and sensory quality of the yellow "téa lémi" wine made in the far-North of Cameroon. J. Food Qual., Vol. 2021. 10.1155/2021/6634747.
29. Marszałek, K., S. Skąpska, Ł. Woźniak and B. Sokołowska, 2015. Application of supercritical carbon dioxide for the preservation of strawberry juice: Microbial and physicochemical quality, enzymatic activity and the degradation kinetics of anthocyanins during storage. Innovative Food Sci. Emerging Technol., 32: 101-109.
30. Alzagtat, A.A. and R.Y. Eledody, 2016. Conformity of fruit nectar samples to Libyan specification standards. Turk. J. Agric. Food Sci. Technol., 4: 524-530.
31. Hidalgo, C., M.J. Torija, A. Mas and E. Mateo, 2013. Effect of inoculation on strawberry fermentation and acetification processes using native strains of yeast and acetic acid bacteria. Food Microbiol., 34: 88-94.
32. Téllez Morales, J.A., B. Henández Santos and J. Rodríguez Miranda, 2021. Impact of the melon juice clarification method on the physicochemical properties of an alcoholic beverage. J. Food Process. Preserv., Vol. 45. 10.1111/jfpp.15427.
33. Al-Mohammadi, A.R., A.A. Ismaiel, R.A. Ibrahim, A.H. Moustafa, A.A. Zeid and G. Enan, 2021. Chemical constitution and antimicrobial activity of kombucha fermented beverage. Molecules, Vol. 26. 10.3390/molecules26165026.
34. Lobnibe, I., 2018. Drinking pito: Conviviality, popular culture and changing agricultural production at the rural–urban interface in Brong Ahafo, Ghana. Afr. Geog. Rev., 37: 227-240.
35. Aka, S., B. Dridi, A. Bolotin, E.A. Yapo, M. Koussemon-Camara, B. Bonfoh and P. Renault, 2020. Characterization of lactic acid bacteria isolated from a traditional Ivoirian beer process to develop starter cultures for safe sorghum-based beverages. Int. J. Food Microbiol., Vol. 322. 10.1016/j.ijfoodmicro.2020.108547.
36. Lyumugabe, F., J. Gros, J. Nzungize, E. Bajyana and P. Thonart, 2012. Characteristics of African traditional beers brewed with sorghum malt: A review. Biotechnol. Agron. Soc. Environn., 16: 509-530.
37. Peleg, M., 2022. A new look at models of the combined effect of temperature, pH, water activity, or other factors on microbial growth rate. Food Eng. Rev., 14: 31-44.
38. Stringini, M., F. Comitini, M. Taccari and M. Ciani, 2009. Yeast diversity during tapping and fermentation of palm wine from Cameroon. Food Microbiol., 26: 415-420.
39. Aiello, F., D. Restuccia, U.G. Spizzirri, G. Carullo, M. Leporini and M.R. Loizzo, 2020. Improving kefir bioactive properties by functional enrichment with plant and agro-food waste extracts. Fermentation, Vol. 6. 10.3390/fermentation6030083.
40. Dongdem, J.T., J. Abugri and C.A. Asakedola, 2020. Chemical composition and microbial contaminants of poha beer: A local nonalcoholic beverage in the Bolgatanga municipality, Ghana. Int. J. Microbiol., Vol. 2020. 10.1155/2020/8861785.