Development, Carbonation and Characterization of Local Millet Beverage (Kunu)

[1]Otaru, A.J., [2]Ameh, C.U., [3]Okafor, J.O., [4]Odigure, J.O., [5]Abdulkareem, A.S and [6]Ibrahim, S.

[1, 3, 4&5](Department of Chemical Engineering, Federal Univeristy of Technology, PMB 065, Gidan Kwanu, Minna, Niger State, Nigeria).

[2](Chevron Nigeria Limited, 2 Chevron Drive, Lekki, Nigeria)

[6](Ovecon Engineering and Consultancy, P.O. Box 1730, Zaria, Nigeria)

ABSTRACT

The need to improve on the quality of local millet beverage (kunu) and the widespread effort in developing countries like Nigeria to develop carbonated drink from locally source materials gave birth to this research work. The aim of this research is to analyze the shelf-life of the product to see if carbonation could extended the shelf-life of the product giving the drink a more refreshing sensation without interfering with the properties of the drink. Because the production of local millet beverage is not standardized, the local traditional technology was used in preparing the drink and carbonation was done using a pure CO_2 extinguisher. Four (4) samples of the drink were made; sample 1 contained CO_2 and citric acid, sample 2 contained CO_2, sample 3 contained citric acid and sample 4 contained nothing (still sample). The products were analyzed for total solid, pH, protein, ash, acidity, moisture content and trace elements. Sensory evaluation and microbiological analysis were also carried out for each sample. In analyzing the product shelf-life which started fermenting after 72 hours, followed by the sample containing CO_2 only (sample 2). The samples analyzed were not refrigerated during the period of storage. It was found that the sample with the highest gas volume has the best shelf-life and the non-carbonated sample yielded easily to microbial growth. Therefore, this research work clearly shows that the development of a carbonated millet drink is practically possible, cost effective and has numerous advantages with other available carbonated drinks.

Keywords: *Kunu, Carbonation, Shelf life, Nigeria.*

I. INTRODUCTION

Millet drink (Kunu), is a nutritious non-alcoholic drink that is produced from various cereal grains such as millet. Kunu is a drink that has found great appeal in the northern part of Nigeria, its consumption is spread over every class of personality and it is consumed either as a food supplement or thirst quencher. The availability of kunu as an alternative for carbonated drinks products which have little to nutritional benefits that is cheaply available for every class of individual. Kunu is one of the complex mixtures which contain macro-molecules such as protein, carbohydrates and lipids (Gafa et al, 2002). The major important cereals which are used in the preparation of kunu are millet, maize, guinea corn and rice. During the preparation of kunu, the ingredients needed are ginger (zingiber officimals), alligator pepper (afromonium melegueta), red pepper (capsicum species), black pepper (piper guineense) and kakandoru or eru. All these ingredients perform one function or the other in the course of the preparation. The most abundant constituents of kunu is water and it acts as the medium in which all other constituents are dissolved and contain only traces amount of in-organic substances. The high nutritive value of kunu is attributed due to the presence of protein, carbohydrates and in particular, vitamin B (Wakil, 2004).

Kunu is taken after meal as a supplement or to quench thirst. Kunu is widely accepted as food drink in some urban centres especially in the Hausa land. The quality and quantity of the products depend largely on the quality of the ingredients and handling technique in the course of production by the producer. The product could be obtained quantitatively after 2 days and it could be stored for another 3 days when refrigerated (Wakil, 2004). It has however been reported that, if kunu is kept overnight in hot season without being refrigerated, its quality begins to deteriorate and this may lead to the spoilage which when consume could constitute danger to health (Adebayo et al, 2010). Spoilage of this product from observation occurs from improper handling, constant fermentation of the ingredients especially the carbohydrates and enzymatic action on the substrates (Wakil,

2004). Hence there is need for proper formulation and carbonation of the product.Carbonated drinks are desired and preferred because of it sharp, unique and refreshing taste. Carbonated drinks are non-alcoholic beverages that consist of CO_2, water, flavouring and some other types of sweet syrup (Abdulkareem et al, 2010). The CO_2 when introduced increases the acidity level of the drink, thereby keeping some micro-organisms from growing. The thrives of microbes in a drink is what usually reduces the shelf-life of the product (Julio et al, 2011). Carbonated millet beverages (kunu) are expected to make a lot of difference when compared to other available carbonated drinks because of it nutritive values among many other properties which include:

[1] Its ability to aid digestion and absorption of components into the body system.
[2] Boosting the immune system of the body against microbial attack.

Currently in Nigeria, soft drinks are very expensive to buy. A bottle of 50cl costs an average price of ₦80.00. The soft drinks have little or no nutritive value because they contained high concentration of sugar and artificial concentrates (The Nation, 2012). Kunu however seem to be highly nutritious with relatively low cost of production and consumption. It is being prepared from our local cereals which are very common and are part of our stable food substances. The problem facing the satisfaction derived from kunu comes from its fast deterioration due to microbial activities causing its spoilage. Therefore, the need to enhance the shelf-life of kunu and to make it more refreshing and appealing gave birth to this research study aimed at the development and characterization of carbonated local millet beverage (kunu).

II. EXPERIMENTAL METHODOLOGY

This section presents a step by step account of experimental procedure carried out in the determination of the properties necessary or that must be possessed by carbonated millet beverage (kunu).

Collection of sample materials

The raw materials for the preparation of the kunu were purchased from a major market in Minna, Nigeria. These materials include millet, alligator pepper, kakandoru, sweet potatoes.

Sample preparation

1kg of millet grains were cleaned and steeped in twice its volume of water (2L) for 24h. Thereafter the steeped grains were washed and spices added. The spices added were ginger, red pepper, cloves and black pepper. The steeped millet grains and spices were then milled in a grinding machine and sieved to remove the shafts after which the supernatant was decanted from the slurry. The slurry was divided into two equal halves with one half added to boiling water while stirring for 2 minutes, cooled to a temperature of 35^{o}C and subsequently added to the remaining half slurry. Adequate amount of water was added to the mixture, stirred and left to settle. After which, the mixture was sieved using a muslin cloth and the filtrate was sweetened with granulated sugar and mixed properly to obtain the freshly processed millet beverage. The product was bottled in plastic bottles.

Carbonation of the products

Carbonation is often one of the last processes in the production of carbonated soft drinks and beer. Thus the carbonation process is critical not only to the final taste and appearance of the product, but influences the filling of the final beverage. To carbonate the product, it was first pre-chilled in a refrigerator to lower the temperature of the product to about 2-4^{o}C for easy absorption of CO_2.Due to the unavailability of a carbonating machine in the laboratory, carbonation of the product was done using a pure CO_2 fire extinguisher. One end of a hose was attached to the mouth of the extinguisher and the other end attached to the bottle mouth of the product. The extinguisher lever was gently pressed to release CO_2 gas into the product and the bottle was sealed immediately for freshness. Sample 1, 2, 3 and 4 were made; sample 1 contained CO_2 and citric acid, sample 2 contained CO_2, sample 3 contained citric acid and sample 4 contained nothing (still sample). Samples 3 and 4 are the drinks that were not carbonated and sample 1 and 2 were the carbonated drinks.

Physiochemical Characteristics of Kunu Beverage

Determination of pH

10ml of the millet drinks was shaken with 100ml of water and allowed to stand for a period of 30minutes. The material was filtered and the pH of the filtrate was determined with a pH meter.

Determination of Titratable Acidity

100ml of the millet drink was shaken with 200ml of CO_2 in a conical flask and placed in a water bath at 40^{o}C for one hour with the flask loosely stopper. It was filtered and 100ml of the clear filtrate was titrated with 0.05M of NaOH solution with phenolphthalein indictor. The acidity of water extracts increases during storage

Determination of Total Solid

10g of the millet drink was weighed (W_1) into a flat-bottomed metal dish and placed on boiling water for about 30minutes until the liquid evaporated leaving the solid. It was then transferred into an oven maintained at 100^{o}C for 2½h and weighed as W_2. It was then desiccated, cooled and weighed. It was heated in the oven again for 1hour, cooled and weighed. The process was continued until constant weigh W_3.

Determination of Protein

20g of the sample was weighed and placed into a Kjeldahl digestion tube. A Kjeldahl tablet of selenium catalyst and 20cm^3 of concentrated H_2SO_4 were added into the tube. The tube was then placed in the digestion block and pre-heated in a fume cupboard until a clear solution was obtained. After digestion, the tube was removed from the digester cooled and the resulting aliquot solution was diluted with distilled water to 50cm^3. 10cm^3 aliquot of the diluted solution was pipette into the distillation flask containing 20cm^3 of 40% NaOH solution. The content diluted with 40cm^3 water and was distilled using micro-Kjeldahl distillation apparatus. The distillate was retrieved into a receiving flask containing 25cm^3 of boric acid indicator solution. The distillate was titrated with 0.10M HCl solution to purple grey end point.

CO_2 Gas Volume Determination

The sample is equilibrated by gently inverting the sample 20times in 30seconds, then wait for bubbles to settle in the liquid.The sample is then placed under the Zahm Nagel tester and align crown with the piercing device. The snifter valve is then closed in front of the tester. Grasp springs and crossbar were carefully lowered until the piercing needle rests on the crown. The crow is then pierced by forcing the crossbar down with a firm and rapid motion. The head pressure is then released by carefully opening the snifter valve, allow the pressure drop and close the valve quickly.The maximum pressure is then recorded and the crossbar is removed, and a thermometer is inserted immediately and the temperature is recorded. The pressure and temperature recorded were converted gas volume by using a gas volume chart.

Determination of Ash Content

The crucible dish was cleaned, dried ignited, cooled and weighed as W_1. 24.4g of the millet drink was weighed accurately and directly in the dish i.e. W_2. The substance was dried on a boiling water bath and the charred over a Bunsen flame or hot plate in fume cupboard until no more soot was given out. Then, it was then ashed with a muffle furnace at 500^{o}C to obtain W_3.

Determination of Trace Elements

The determination of trace metal contaminants in millet drink was carried out. These trace metals are lead, copper, zinc, manganese and calcium. The organic matter of the food was first destroyed dry ashing 24.4g of Kunu sample between 400-500^{o}C for 5h. This was followed by acid digestion by adding 20ml of H_2SO_4 and 10ml of HNO_3 (2:1). The mixture was heated on Bunsen burner until the brown fumes subsided. Another 10ml of H_2SO_4 was continued at 10minutes interval and heating continued until the solution becomes colourless. The digestion sample was then analyzed for lead, zinc, calcium, manganese and copper using AAS.

Determination of Moisture Content

10g of millet drink was weighed into a pre-weighted flat dish W_1 and dried at an oven temperature of 105^{o}C for 3h as W_2. It was allowed to cool in an airtight desicator and reweighed. It was heated in the oven again for half an hour, cooled and weighed. The process was repeated until constant weigh was obtained W_3.

III. MICROBIOLOGICAL ANALYSIS OF THE PRODUCT

Determination of Yeast and Mould

These were carried out by the pour plate method as described by Nigeria Distilleries Limited (NDL) using nutrient agar and potato dextrose agar for total aerobic bacteria and total yeast count respectively. Nutrient agar was inoculated with a 0.1ml of appropriately 10ml diluted millet drink by spread-plating technique and incubated at 37^{o}C for 24h. Colonies were counted and multiplied by the dilution factor. Colony counts were done after the appropriate period of incubation. Distinct colonies from the poured plate were streaked to fresh sterile nutrients agar plates to obtain pure colonies of bacterial and transferred to agar slants as stock culture for later use.

Sensory Evaluation

The available sample of the millet beverage is given to the respondents with a copy questionnaire to be filled based on the sample with preferred taste, colour, texture, flavour, and general acceptability.

Shelf-Life Determination

Within the period of storage the following analysis were carried out;

Periodic pH determination

Fermentation rate

Table 1. Sample Description

Sample	Specification
1	CO_2 + citric acid
2	CO_2 only
3	Citric acid
4	Still

Results and Discussion

Experiments carried out in the development and characterization of carbonated local millet beverage (kunu) and various results obtained are presented.

Table 2 Physical Analysis of Local Millet Beverage

Moisture content (%)	86.6
Total solid (mg/l)	853
Protein (%)	1.75
Ash content (%)	0.20

Table 3 pH Variation and CO_2 Content

Samples	pH	Titratable Acidity	Gas volume (cm^3)
1	2.38	0.110	3.0
2	2.42	0.097	2.5
3	2.75	0.083	0
4	3.83	0.063	0

Table 4 Mineral Analysis of Millet Drink

Minerals	Quantity (ppm)	Maximum Permissible Limit in ppm (WHO)
Lead	0.001	0.01
Copper	1.070	100
Zinc	3.100	300
Calcium	4.200	No limit
Manganese	1.020	0.36

Table 5 Microbiological Analysis of Millet Drink

Samples	1	2	3	4
Bacteria count	30	44	54	70
Yeast and mould	1	2	3	4

Table 6 Sensory Evaluation of Millet Drink

Samples	1	2	3	4	Total number of respondent
Respondent	7	4	2	2	15

Table 7 Shelf-life Determination cm^3

1st DAY (24 HOURS)			
Samples	Time (hrs)	Vol. Increase (cm^3)	pH
1	6	-	2.38
	12	-	2.38
	18	-	2.38
	24	-	2.38
2	6	-	2.42
	12	-	2.42
	18	-	2.42
	24	-	2.42
3	6	-	2.75
	12	-	2.75
	18	-	2.75
	24	-	2.75
4	6	-	3.83
	12	-	3.83
	18	-	3.83
	24	-	3.83

IV. DISCUSSION

The various results obtained in the analysis of carbonated local millet beverage (kunu) are presented in Tables 2-6

Table 2 shows the results obtained in the physical analysis of the final product.

2nd DAY (48 HOURS)			
Samples	**Time (hrs)**	**Vol. Increase (cm^3)**	**pH**
1	6	-	2.38
	12	-	2.38
	18	-	2.38
	24	-	2.38
2	6	-	2.20
	12	-	2.20
	18	-	2.20
	24	3.4	2.20
3	6	-	2.30
	12	-	2.30
	18	-	2.30
	24	4.2	2.30
4	6	-	3.41
	12	-	3.41
	18	-	3.41
	24	5.1	3.41

3rd DAY (72 HOURS)			
Samples	**Time (hrs)**	**Vol. Increase (cm^3)**	**pH**
1	6	-	2.10
	12	-	2.10
	18	-	2.10
	24	2.7	2.10
2	6	4.3	1.90
	12	4.8	1.90
	18	5.0	1.90
	24	5.8	1.90
3	6	5.1	1.52
	12	5.8	1.52
	18	6.2	1.52
	24	6.9	1.52
4	6	6.0	1.30
	12	6.8	1.30
	18	7.4	1.30
	24	9.1	1.30

The percentage moisture content of the samples was found to be 86.6%, this is attributed to the fact that water is the most abundant constituent of the product and it acts as the medium in which all other constituents are dissolved. The percentage moisture content also shows the level of the viscosity of the samples as the slurry was diluted with water during preparation. The total solids in the samples, was found to be 853mg/l. The high percentage value of the total solids could be attributed to various ingredients used in the preparation of the samples. It may also reflect the volatile composition of the samples. The percentage protein in the samples was found to be 1.75%. The protein content of the product (kunu) made it to more nutritious than any of the carbonated soft drinks which seem to have contained no protein content. Their major components are sugar, colouring and carbonated water. The percentage ash in the sample was 0.2%. The importance of the ash content is that it gives an idea of the amount of minerals elements present in the samples. It has also been reported that the value of ash is a useful and quality or grading assessment of certain edible materials (AOAC, 1990). This result was also supported by the level of trace elements in the samples.

Table 3 shows the results obtained from the chemical analysis of the final product. The pH of the samples 1, 2, 3, and 4 were found to be 2.38, 2.42, 2.75, and 3.83 respectively. Sample 1 (sample containing CO_2 and citric acid) gave a pH of 2.38 which slightly more acidic compared to the other samples (2, 3, and 4). This is due to the presence of CO_2 and citric acid.

CO_2 when added to the product dissolves in water (the major constituents of the product) forming carbonic acid (H_2CO_3) which in turn increases the acidity of the product. Sample 2 (sample containing only CO_2) gave a pH of 2.43, which is acidic compared to sample 3 and 4 due to the formation of carbonic acid between CO_2 and water, but a little less acidic than sample1 because sample 1 contains citric acid which also influences the pH of the product. Sample 3 (sample with citric acid) gave a pH of 2.75 more acidic than sample 4 due to the presence of citric acid. And sample 4 (still sample) gave a pH of 3.83 which is less acidic than the other samples because it contains no CO_2 or citric acid.

The percentage titratable acidity was found to be 0.11%, 0.097%, 0.083%, and 0.063% for sample 1, 2, 3 and 4 respectively. The varying values obtained for each sample is attributed to the presence of CO_2 or citric acid or both. It was observed that the percentage titratable acidity decreases as the pH increases from sample 1 to 4. This implies that the more acidic the sample is the more NaOH volume it would require to neutralize it.Table 4 shows the results obtained for the major, essential trace and toxic elements. The major element is calcium while the trace elements are zinc, copper and manganese and toxic element is lead. The result revealed that calcium has the highest concentration (4.20ppm) followed by zinc (3.10ppm), then copper (1.07ppm), then manganese (1.02ppm) and the least is lead (0.001ppm). The quantity of trace elements were relatively low for lead (0.001ppm), copper (1.07ppm), manganese (1.02ppm) compared with their tolerant limit. This is very good results from the biological point of view. However, calcium which is essential requirement for bone development and strong teeth and zinc which aid digestion and body functions were relatively high (zinc, 3.10ppm), (calcium, 4.20ppm). The concentration of manganese is relatively moderate because it becomes poisonous when taken in high concentration.

Table 5 shows the results of the microbial analysis of the final product. For the bacteria, yeast and mould count, the non – carbonated sample 4 has the highest count of 70 and 4 respectively probably because of its low acidic content and a gradual decrease in the bacteria, yeast and mould count was observed for the carbonated samples 1 and 2. Carbonated sample 1 has the lowest bacteria; yeast and mould count of 30 and 1 respectively. This could be attributed to high acidic medium which inhibits the growth of micro organisms. The presence of some of the bacteria may be due to contamination from the substrate, the environment during production, the hygienic state of the processing of the sample. While the presence of fungi may be attributed to the acidic nature of the sample since it has been observed that yeast and mould are capable of utilizing organic acids. Also the presence of fungi in the food may lead to poisoning and contaminated fungi result in the production of undesirable odour, colour changes and even the taste of the sample will be changed. The general observation from the microbial analysis shows that as the medium becomes more acidic the concentration of micro-organisms continues to reduce.

Table 6 shows the results of the sensory evaluation of the final product. A total number of 15 respondents were recorded for all the samples. The non-carbonated sample 3 and 4 has the lowest acceptance number of 2 respondents while carbonated sample 1 has the highest number of respondents of 7. This was considered the most acceptable because of the fizzling and refreshing taste produced by the CO_2 gas. However, carbonated sample 2 also recorded 4 respondents. This was considered to be so perhaps because of the low carbonic acid concentration present.

Table 7 shows the evaluation for the shelf-life of the final product carried out at six hours interval. Kunu as it is known as a very short shelf-life and it would be still acceptable after approximately 48hours without refrigeration. The short shelf-life is attributed to the microbial activities causing fermentation in the final product which will eventually cause spoilage of the product. In this study, the fermentation rate of each of the samples is observed by the swelling (volume increase) of the bottles in which the samples are kept. The swelling or volume increase of the sample bottles with time is the same as the rate of fermentation. The general observations from the tables show that as pH decreases for each sample, the rate of fermentation increases implying that the rate of fermentation is invariably proportional to the pH of the product. Results as presented also indicate that as the pH decreases the titratable acidity of the samples increased. During the first 24hours of storage all samples recorded no volume increase and their pH were still stable. In the second 24hours (48hours) of storage, sample 1 (sample containing CO_2 and citric acid) recorded no volume increase and its pH was still stable. But the rest of the sample 2, 3, and 4 (sample 2 containing CO_2, sample 3 containing citric acid, and sample 4 the still sample) recorded volume increase of $3.4cm^3$, $4.2cm^3$, and $5.1cm^3$ with pH drop of 2.20, 2.31, and 3.41 respectively at the end of the second 24hours.

This indicated that fermentation had begun in the samples. Sample 1 recorded a volume increase of 2.7cm^3 and a pH drop of 2.10 after 72 hours of storage while the rest of the samples recorded steady volume increase and pH drop within the 72 hours of storage. This implies that sample 1 is the best among all the samples, it is presumed to last for over 72hours. Therefore, the shelf-life of the developed carbonated millet beverage was extended by roughly another 24hours.

V. CONCLUSION AND RECOMMENDATION

In this study, carbonated millet drinks was developed and characterized to determine the suitability of the drink as an alternative carbonated source from local materials. Results obtained revealed that both chemical and microbial characterization of the millet drink (kunu) reflects that the product contained no harmful micro-organisms or by-product. The micro-organisms encountered in this study of indigenous fermented food drink (kunu) was as a result of contamination from one source or the other which include water, air, equipment or utensils used in processing, personal hygiene etc. These bacterial are non pathogenic and human commensalisms, hence they cannot transfer disease.It was found that the sample with the highest gas volume has the best shelf-life and the non-carbonated sample yielded easily to microbial growth. Therefore, this research work clearly shows that the development of a carbonated millet drink (kunu) is practically possible.

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