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## Physico-chemical and bacteriological analyses of banana juice produced and consumed in Bweramana (Rwanda)

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**Abstract:** Banana juice and other derivatives foods of banana are of most important to Rwandan peoples. Although such highly preferred, if banana juice is not well processed and preserved it may lead to different diseases. The aim of this study is the biological and physico-chemical analyses of banana juice produced and consumed in Bweramana sector of Rwanda. Samples were analyzed for yeasts and molds which were found to be of  $9.0 \times 10^1$  cfu/mL; total mesophilic aerobic flora with  $2.0 \times 10^4$  cfu/mL which was found to exhibit the very high value. Interestingly, salmonella and shigella the same as *Escherichia coli* were absent. Fecal coliforms and RAS (anaerobic) were both of them found with a low value; <1 cfu/mL. The total *Staphylococcus aureus* and *Streptococcus fecal* count were in the range of  $7.0 \times 10^1$  cfu/mL and  $7.0 \times 10^2$  cfu/mL respectively; and total coliforms with count  $4.4 \times 10^2$  cfu/mL. All the samples were of acidic pH ranging between 4.69-4.78; total acidity 4.5 g/L and total sugars with 60g/L. Overall, the study demonstrates unsatisfactory hygienic practice during the preparation of that beverage and it needs to be microbiological controlled in order to ensure health safety.

**Key words:** Banana juice, microbiological quality, physico-chemical analyses.

## INTRODUCTION

Banana is one of the oldest cultivated plants; and the second major food crop in Rwanda<sup>1</sup>. It is used both as food and cash crop<sup>2</sup>. Banana juice is widely used in wedding ceremonies and other parties and it is the most appreciated drink by local people. Banana juice constitutes a valuable source of energy, vitamins and minerals. It is helpful in digestion by regulating digestive tract, helping in secretion of digestive enzymes, improving taste of the mouth and increasing appetite. Bananas have long been recommended as dietary supplements for individuals suffering from digestive disorders for their richness in hemicelluloses content than most fruits and vegetables and high amount of essential minerals such as potassium, and various vitamins such as A, B<sub>1</sub>, B<sub>2</sub> and C<sub>3</sub>.

Like other juices, banana juice is a complex solution containing sugar, different salts, acids and other chemical substances that can contribute to the decomposition by microorganisms during storage although some preservatives are used to increase their time of storage. The low pH, the high sugar concentrations<sup>4</sup> and water<sup>5</sup> used for dilution are the major sources of microbial contaminants including coliforms, fecal coliforms, fecal streptococci, etc in this beverage.

In Rwanda, the tradition production of banana juice is still basically starting from ripening of bananas mixed with spear grass, followed by extraction. The extraction is generally done under poorly hygienic conditions by men; by squeezing their feet or hands until all the pulp is exhausted of juice<sup>6</sup>. Filtration is made through grass held in calabash funnel and an amount of water is added for dilution depending on the quality needed<sup>7</sup>. With this traditionally method, it is clear that the processing is highly prone to microbial contamination. Indeed, microbiological safety of indigenous beverage is a crucial issue in many developing countries; including Rwanda<sup>8, 9</sup>. On public health level, several reports displayed by Gitwe hospital located in Bweramana sector and surrounding health centers reveal that there is a prevalence of diarrheic infection mostly in this area.

To the best of our knowledge scientific studies reported on the microbiological and physico-chemical of banana juices consumed in Rwanda and in the region are too low. The aim of this study is therefore to assess the hygienic-sanitary quality and to determine the physico-chemical parameters of the banana juice consumed in Bweramana sector of Rwanda.

## MATERIALS AND METHODS

**Sample collection:** Samples were collected in triplicates into sterile screw cap bottles from different local sellers who were chosen randomly. Samples were transported to the laboratory in ice-box; and kept at temperatures between 0 and 4°C before analyses without any other conservative agent. Before analyses, they were shaken vigorously to ensure a uniform distribution of microorganisms and other nutrients.

**(a) Physico-Chemical analyses:** pH and conductivity were measured using the electrochemical method. The multimeter device used was immersed in sample juice and the results were recorded. Titratable acidity was determined by volumetric titration using a 0.25 mol/L KOH solution with phenolphthalein as indicator. Total sugar and Viscosity were measured by using hydrometer and Ostwald viscometer respectively.

**(b) Microbiological analyses:** All samples were diluted as 1:10 with buffered peptone water and then plated on nutrient agar plate, on different selective media to assure their colony-forming unit. After inoculation, the plates were incubated at 37°C for 24-48 hours except for *Escherichia coli* and fecal coliforms at 44°C and at 25°C for yeasts and molds.

## RESULTS AND DISCUSSION

**(a) Microbiologic results:** From the results of microbiologic analyses presented in **Table 1**, it is clear that different microorganisms are present in the banana juice produced locally and consumed in Bweramana sector. For all microorganisms analyzed only, *Escherchia coli* the same as Salmonella and Shigella were absent. This is interesting because the presence of coliforms in fruit juice is highly toxic as it is a source of diarrhea, urinary infections, pyogenic infections and septicemias<sup>10-11</sup>. Indeed, *E. coli* is not allowed by safe food consumption standard<sup>12</sup>; although some researchers found them in fruit juices with high concentrations up to  $10^4$  cfu/mL<sup>13, 15, 17</sup>.

Another interesting aspect in analyzed samples is that fecal coliforms and RAS (anaerobic) are present but their concentrations are low  $<1$  cfu/mL. Therefore, we can assume that no contamination can come from those microorganisms, but consumers should always take care about diseases that can come from other microorganisms. However, other microorganisms are of high concentrations and this situation is alarming. Firstly, the enumeration of *Staphylococcus aureus* was found to be  $7 \times 10^1$  cfu/mL. The high presence of staphylococci in the sample of juice may be due to severe contamination through handling. Considering that staphylococci are frequently present on the hands, skin and in the upper respiratory tract of humans, these contaminants may probably find their origin from the food handlers and with grass mainly used during extraction of the banana juice. Moreover, coagulase-positive staphylococci may cause disease through the production of toxins; and many researchers have reported the prevalence of staphylococci in fruit juice samples<sup>14-15</sup> that can go up to  $8.99 \times 10^5$  cfu/mL; a very big concern for public health<sup>16</sup>.

**Table 1:** Results for biological analyses

Microbiologic germ	Sample 1 (cfu/mL)	Sample 2 (cfu/mL)	Sample 3 (cfu/mL)	Mean (cfu/mL)
Yeast and molds	$8.9 \times 10^1$	$9.1 \times 10^1$	$9.0 \times 10^1$	$9.0 \times 10^1$
Total aerobic mesophilic flora	$1.5 \times 10^4$	$2.4 \times 10^4$	$2.1 \times 10^4$	$2.0 \times 10^4$
Salmonella and Shigella	Not detected	Not detected	Not detected	Not detected
Total coliforms	$4.0 \times 10^2$	$4.7 \times 10^2$	$4.5 \times 10^2$	$4.4 \times 10^2$
Fecal coliforms	$<1$	$<1$	$<1$	$<1$
<i>Staphylococcus fecal</i>	$6.9 \times 10^2$	$7.2 \times 10^2$	$6.9 \times 10^2$	$7.0 \times 10^2$
<i>Staphylococcus aureus</i>	$6.8 \times 10^1$	$7.1 \times 10^1$	$7.1 \times 10^1$	$7.0 \times 10^1$
RAS (anaerobic)	$<1$	$<1$	$<1$	$<1$
<i>Escherchia coli</i>	Not detected	Not detected	Not detected	Not detected

Secondly, total viable count or mesophilic aerobic flora total were found with high value of  $2.0 \times 10^4$  cfu/mL; and the enumeration of *Streptococcus fecal* is  $7 \times 10^2$  cfu/mL which is also high the same as total coliforms count (TCC) which was exhibited to be  $4.4 \times 10^2$  cfu/mL. It is capital to mention out that *Streptococcus fecal* and total viable count in the juice are a cause of toxin-infection and may gain entry through water used for dilution. This statement is quite in true by other previous authors who reported contamination juices by street vended fruit juices with fecal coliforms and fecal streptococci due to poor quality of water used in dilution as well as prevailing unhygienic conditions related to washing of materials and premises<sup>17</sup>. The presence of different fecal coliforms in drinking juices is alarming hence they may cause serious diseases in human beings.

The yeasts and molds counts were  $9.0 \times 10^1$  cfu/mL. High mold or bacteria counts are indicatives of poorly cleaned equipment and high yeast or lactic acid forming bacteria may also be indicative of fermentation of the juice. The yeasts play important role in food and beverage spoilage<sup>18</sup> and they are in general involved in the deterioration of fruit juices because they tolerate low pH values and low temperatures<sup>19</sup>; key factors that favor their growth. The microbiologic results of this study clearly indicates the poor hygienic conditions of this juice and this explains the use of contaminated water during handling and the washing of materials used in processing of this beverage.

**(b) Physico-chemical results:** according to the results presented in **Table 2**, banana juice samples have shown acceptable values. Firstly, total sugars were found to be of 60 g/L and this is a reflection of increased dilution of this juice either by sellers or by venders and can have negative impact by reducing juice sweetness thus making the juice non attractive to consumers<sup>20</sup>. Secondly, total acidity and pH were found to be 4.5 g/L and 4.76, respectively. pH is one of the important quality parameters that describes the stability of bioactive compounds in fruit juices<sup>29</sup>. Acidity of juice is responsible of the taste of the juice. In fact if the acidity is too low, the juice lacks freshness. On the other hand, too much acidity may render the juice too sharp and unpleasant to drink, thus it should be in equilibrium. The pH is related with the biochemical reactions that occur in the fermenting the juice. pH has shown a potential protection of fruits juice. For example, it has been proven that a pH lower or equal to 3.0 gives an acidity level which is normally sufficient to protect the juice from the spoilage due to unwanted micro-organisms. The pH value found in our study is similar to values ranging from 4.37 to 4.74 reported by other previous studies on banana juices<sup>21-24</sup> and the total acidity reported in this study is also in agreement with other values reported by previous authors<sup>23, 25, 26</sup>.

**Table 2:** Physico-chemical results for the analyzed banana juice parameters

Parameter	Sample 1	Sample 2	Sample 3	Mean
Color	U	U	U	U
Odor	U	U	U	U
pH	4.69	4.81	4.78	4.76
Total sugars	62	58	60	60 g/L
Density	1.0501	1.0479	1.0484	1.0488 g/mL
Total acidity	4.6	4.4	4.5	4.5 g/L
Viscosity	1.758	1.735	1.739	1.744 Pa s
Conductivity	1413	1421	1426	1420 $\mu\text{s}/\text{cm}$

**U: Unobjectionable**

The results of **Table 2** show that the banana juice produced in Bweramana sector has a density of 1.0488 g/L which is high comparatively to the density of water (1 g/L). However, the density values found in this work are similar to those reported on banana juice by the previous authors<sup>24</sup>. The high density for this juice is due to the increasing of soluble solids because it has been demonstrated that density is strongly affected by soluble solids concentration; and it is also very slightly affected by temperature<sup>27</sup>. When the density of the juice is high the temperature to boil it should also be high<sup>28</sup>. Due to this statement, the banana juice produced in Bweramana sector shall require higher

temperatures for being boiled which is not economic for those rural citizens from Bweramana sector who will be obliged to use more firewood or charcoal which is so expensive.

Viscosity is another parameter after density, which is affected directly by solid present in juice. The principal solids constituents of clear banana juices are sugars; mostly glucose and fructose. The results of **Table 2** show that the viscosity value was found to be 1.744 Pa s. This value is closed to the viscosity value obtained on similar study conducted on grape juice<sup>27</sup>. Finally, the results obtained in **Table 2** demonstrate that the conductivity is 1420  $\mu\text{s}/\text{cm}$ .

## CONCLUSION

The main objective of this study was the physico-chemical and microbiological analysis of banana juice consumed in Bweramana Sector of Rwanda. The results of this study are alarming due to the findings of some biological parameters that are out of recommended range values; due to poorly hygienic conditions during extraction and storage conditions. It should be pasteurized to respect the minimum required hygienic conditions. Although the results of this study do not provide complete interpretation of the microbial diversity of banana juice consumed in Bweramana, it is the first study conducted in this area and therefore, regular microbiological monitoring should be carried out to prevent any future contamination outbreak.

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