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PHYSICAL AND MORPHOLOGICAL CHARACTERISTICS, VITAMIN AND MINERAL COMPOSITION, AND MICROBIOLOGICAL QUALITY OF *ANANAS COMOSUS* L. MERR. (BROMELIACEAE) FRUIT GROWN IN FOULAYAH (KINDIA-GUINEA)

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ABSTRACT

This study forms part of the chemical and microbiological characterisation of a new pineapple crop of the 'Baronne' variety in Foulayah, in the Kindia prefecture. Using standard methods and reference standards, we determined several physico-chemical parameters, namely weight, shape coefficient, colour, pH, moisture content, acidity, ash content, total sugars, vitamins C and B2, the minerals K and Ca, total polyphenols and flavonoids, as well as the microbial flora. The results showed that the fruits analysed had an average weight of 1436.47±4.63 g, an elongated shape (Cf >1), a yellow-green colour, and a high water content (85.39±1.26%), an acidic pH of 4.43±0.01 with an acidity of 0.84±0.13% citric acid equivalent. The total sugar content was found to be 10.78±0.05%, and the ash content 0.21±0.03%. The fruit is rich in vitamin C (13.81±0.26 mg/100g) and contains less vitamin B2 (28.37±0.12 µg/100g). The potassium and calcium values are 108.34±1.47 mg/100g and 11.53±0.22 mg/100g respectively. The amounts of phenols and flavonoids are 23.05±0.04 mg/g gallic acid equivalent and 11.26±0.06 mg/g quercetin equivalent, respectively. Bacterial counts were 3.103/g for mesophilic flora and 108/g for yeasts and moulds, indicating good microbiological stability in accordance with the standard.

KEYWORDS: Foulayah, pineapple, physicochemical, microbiological, polyphenols, flavonoids.

1. INTRODUCTION

The Republic of Guinea, a West African country with a humid tropical climate, boasts remarkable agri-food biodiversity. Among its fruit crops, the pineapple (Ananas comosus L. Merr.) plays a prominent role, particularly in Kindia Prefecture, often referred to as Guinea's pineapple capital. This region benefits from exceptionally favourable soil and climate conditions: rich ferralitic soils and annual rainfall exceeding 1,800 mm (FAO, 2019). The pineapple belongs to the Bromeliaceae family. It is a perennial herbaceous plant native to South America, the cultivation of which has spread to all tropical and subtropical regions of the world (Paull & Chen, 2003).

From an agri-food perspective, the organoleptic and nutritional quality of the pineapple depends closely on the variety grown, the stage of ripeness at harvest, the climatic and soil conditions of production, and post-harvest practices (Hossain et al., 2015).

The Kindia pineapple is renowned for its particularly sweet flesh and pronounced aroma. Its production represents a vital source of income for thousands of farming households in the region. According to data from Guinea's National Directorate of Agriculture (2022), national pineapple production stands at around 200,000 tonnes per year, of which more than 40 per cent comes from the Kindia area and its immediate surroundings.

According to FAO statistics (FAOSTAT, 2021; Sankhon et al., 2023), pineapple ranks eleventh among the world's cultivated fruits. In West Africa, pineapple is the second most important tropical fruit in terms of production, after the banana (Sankhon et al., 2023)

In Guinea, pineapple production is mainly concentrated in the Kindia, Mamou and Labé regions. The most widely grown variety in Kindia Prefecture is the local 'Barronne' variety, characterised by its pale yellow flesh, high sugar content and low acidity. Production is highly seasonal: it is concentrated between April and July, creating a surplus that depresses prices and contributes to post-harvest losses (Mwangi & Wambugu, 2016).

Ripening can be characterised as a stage in the fruit's life cycle during which biochemical reactions are triggered and continue, leading to a transient state that of ripeness in which the fruit's organoleptic qualities reach their peak (Huet, 1958). The enzymatic processes underlying these phenomena, which occur in pineapples, take place simultaneously throughout the fruit. Firstly, the breakdown of ascorbic acid, the formation of sucrose, followed, a few days later, by the decarboxylation of acids. Despite this undeniable production potential, the pineapple sector in Guinea continues to face considerable structural challenges for producers, which contribute to food insecurity in a region where malnutrition remains a cause for concern.

Against this backdrop, there is a steadily increasing trend towards the development of new production techniques involving the use of agricultural inputs that may affect the fruit. It is therefore essential to carry out continuous quality control of fresh fruit intended for direct consumption, in order to monitor its composition and ensure quality with regard to its use. The overall objective of this study is to contribute to the quality of the locally grown 'Baronne' pineapple, newly produced in Kindia, by determining its vitamin, mineral and primary and secondary metabolite composition.

2. MATERIAL AND METHODS

2.1. Material

The pineapples were harvested in Foulayah, one of the region's main production areas, with 10 fruits grown in 2026. The harvested fruits were at commercial maturity, with skin colour ranging from green to yellow (Figure 1). To carry out the various analyses, the samples were washed with distilled water, peeled by hand and completely stripped of their skin. The flesh was then cut cross-sectionally using a knife that had been previously disinfected with sodium hypoclhoride.



Fig. 1: Pineapple grown in Foulayah in 2026 (Baronne).

2.2. Methods

✓ **Morphological analysis**

The set of ten fruits represents the carefully selected sample. The morphological characteristics of the fruits are expressed by the average fruit weight (Pm), colour and the shape coefficient Cf, calculated using the formula by Fagbohoun and Kiki (1999), as applied by Dossou (2007).

$$Cf = \frac{Average\ fruit\ heigh}{Average\ fruit\ diameter}$$

The Cf coefficient is used to classify varieties into three shape categories, namely: Cf < 0.8: flattened shape; 0.8 < Cf < 1: round shape; and Cf > 1: elongated shape.

✓ **Hydrogen potential**

The pH was measured directly in the 10% aqueous solution of pineapple fruit pulp using a pH meter calibrated with buffer solutions certified by HANNA Instruments at pH 4.01 and 7.01 (AOAC, 1995).

✓ **Acidity**

Total titratable acidity was determined by neutralising the juice with a 0.1 N NaOH solution in the presence of 0.1% phenolphthalein as a colour indicator, and expressed as gram-equivalents of citric acid per 100 g of fresh matter (N'Ganzoua et al; 2010; Yeo et al., 2021).

✓ **Total Sugar analysis**

The total sugar and reducing sugar contents were determined using the method described by N'Ganzoua et al. (2010), employing 3,5-dinitrosalicylic acid (DNS) with glucose as the reference standard. In the presence of phenolic compounds, furfural produces an orange-yellow colour in a basic medium, the absorbance of which is measured by spectrophotometry at a wavelength of 540 nm. The results will be expressed in grams of glucose equivalent per 100 g of fresh matter. The sample is prepared by grinding 5 g of pineapple pulp in 20 ml of 99.5% ethanol. The mixture is thoroughly ground in a porcelain mortar and then centrifuged at 1000 rpm for 15 minutes. The supernatant is collected and the volume is made up to 20 ml with ethanol. Table 1 below sets out the calibration procedure using a 1000 ppm stock solution.

Table 1: Preparation of standard solutions for sugar analysis.

Tubes	T1	T2	T3	T4	T5	T6
Volume of standard (mL)	0	0.2	0.4	0.6	0.8	1
Volume of distilled water (mL)	1	0.8	0.6	0.4	0.2	0
DNS* reagent (mL)	3	3	3	3	3	3

*DNS : Dinitro-3,5- salycilic Acid

The same procedure is followed for the sample containing 0.5 mL and 0.8 mL of pineapple juice respectively. The volumes of distilled water and reagents are the same.

✓ **Determination of total ash**

Ash content was determined by incineration in a muffle furnace at 550°C for 5 hours (AOAC method 940.26; AOAC International, 2016).

✓ **Mineral analysis**

Mineral elements such as potassium (K) and calcium (Ca) were analysed by atomic absorption spectrometry on solutions of the ash in dilute hydrochloric acid, following the method described by Sawadogo et al. (2014); Gandonou et al. (2019); Yeo et al. (2021). The calcium ion reacts with the methylthymol blue (BMT) indicator in an alkaline medium; the intensity of the Ca-BMT complex, measured at 612 nm, is proportional to the amount of calcium present in the pineapple sample.

✓ **Determination of water content**

This was determined using the method described by Ramahatoraka (2007). The difference between the weight of the sample before and after drying is used to calculate the moisture content of these products. After drying at 103°C ± 2, the capsule is cooled in a desiccator for 30 minutes and then weighed. The moisture content (H%), expressed in grams per 100 grams of sample, is given by the following formula: $H(\%) = 100 \times (m1-m2) / (m1-m0)$,Where m0: mass in grams of the empty capsule; m1: mass in grams of the capsule and sample before drying; m2: mass in grams of the capsule and sample after drying.

✓ **Determination of Vitamin C.**

The vitamin C assay was carried out according to the methods described by Bender and David (2003); Sethi (2006); and Gaurav et al. (2011). A stock solution of ascorbic acid at 0.5 mg/mL in 3% potassium hydrogen phosphate was prepared. Diluted solutions of increasing concentrations were prepared: 5; 10; 20; 25 and 50 µg/mL. Subsequently, 5

mL of each solution was transferred to a 25 mL volumetric flask, to which 2 mL of sulphuric acid (10% v/v) and 5 mL of ammonium molybdate (10% m/v) were added respectively. To prepare the sample, 10 mg of pineapple pulp was weighed into a 20 mL volumetric flask. After adding a specified quantity of a 3% potassium hydrogen phosphate solution, the mixture was placed in an ultrasonic bath for 15 minutes and then made up to the mark to give a concentration of 0.5 mg/mL. 5 mL of the sample was transferred to a 25 mL volumetric flask. To each volumetric flask, 2 mL of sulphuric acid (10 % v/v) and 5 mL of ammonium molybdate (10 % m/v) were added and mixed thoroughly, then left to stand for 50 minutes at room temperature. After thorough mixing and incubation for 1 hour at room temperature, the absorbance was measured at 450 nm using a UV-visible spectrophotometer against a blank. Two replicates were carried out.

✓ **Determination of vitamin B2**

Vitamin B2 was quantified using the spectrophotometric method described by Gaurav et al. (2011). In a 100 mL volumetric flask, 50 mg of vitamin B2 in the form of thiamine hydrochloride was weighed out, followed by the addition of 50 mL of milliQ distilled water, which was then sonicated until completely dissolved. The volume was made up to the mark with the same solvent. The vitamin B2 stock solution thus prepared had an initial concentration of 500 µg/ml. Successive dilutions were then carried out in distilled water to obtain a range of increasing concentrations: 5; 8; 10; 15 and 20 µg/mL. The solutions were then filtered using sterile 0.45 µm discs fitted to 5 cc (cubic centimetre) syringes. 5 ml of each diluted solution was transferred into labelled test tubes. To each test tube, 5 ml of NH_4OH (0.1 M) and 0.5 ml of 4-aminophenol solution were added and mixed thoroughly, then left to stand for 5 minutes. 10 ml of chloroform were added and the chloroform layer was separated. The absorbance of the organic phase was measured at 430 nm against a blank. The procedure was followed for the sample prepared at a concentration of 0.5 mg/mL. The tests were repeated twice.

✓ **Determination of polyphenols**

125 µL of a 1 mg/mL extract is dissolved in 625 µL of Folin-Ciocalteu reagent. After a reaction time of 5 minutes, 500 µL of sodium carbonate (Na_2CO_3) at 75 mg/mL is added. The mixture is vortexed and then incubated in the dark for 2 hours. The absorbance is measured at 760 nm using T80+ UV/VIS Spectrometer manufactured by PG Instruments Ltd . The polyphenol content is expressed in mg of gallic acid equivalent per gram of pineapple juice (Agbodjogbé et al., 2022; Koudjina et al., 2023; Houngbeme et al., 2026).

✓ **Determination of Flavonoids**

To 500 µL of a 2% aqueous aluminium chloride solution, 500 µL of the hydroethanolic extract is added. 3 mL of methanol is then added, followed by incubation for 10 minutes. Optical density readings were taken using a spectrophotometer at 415 nm against a reagent blank. Quercetin was used as a reference at a concentration of 10 mg/mL in methanol (Houngbeme et al., 2026). The flavonoid concentration by weight is given in mg of quercetin equivalent per gram of pineapple juice (Maiga et al., 2020; Deguenon et al., 2023; Houngbeme et al., 2026).

✓ **Microbiological analysis**

Microbiological analysis was carried out on the pineapple. The parameters assessed will be: total mesophilic aerobic flora (TMAF), total coliforms, yeasts and moulds, in accordance with the applicable ISO standards (ISO 4833 and ISO 21527). The total plate count primarily concerns mesophilic aerobic bacteria that can be revived after 72 hours'

incubation at 30 °C in a well-defined culture medium. The method used is that described in standard NF V 08-051 (AFNOR, 1999). The enumeration of yeasts and moulds was carried out in accordance with standard NF-V 08-022.

3. RESULTS AND DISCUSSION

3.1. Morphological characteristics

The average weight for all the fruits was 1436.47 ± 3.27 g. The colour of the fruits is yellow-green and the shape coefficient Cf is 1.23 ± 0.02. As Cf is greater than 1, this implies that the pineapple fruits analysed are elongated. All these characteristics are consistent with the Baronne variety.

3.2. Physicochemical characteristics

The pH of the pineapple pulp juice measured was 4.43 ± 0.01. This pH indicates that the Baronne pineapple is acidic and therefore acts as a natural protective factor against enteropathogens. However, according to Remize et al. (2020), it promotes the growth of acidophilic yeasts and moulds, which are the main causes of the fruit's organoleptic deterioration (browning, fermented odour, loss of firmness).

The various values of the physico-chemical parameters determined are summarised in Table 2, and Figures 2 and 3 illustrate the calibration curves for vitamins B2 and C.

Table 2: Contents of selected physico-chemical parameters analysed.

Parameters	Content per 100g of fresh matter
Acidity	0.84±0.13
Water content	85.39±1.26
Total ash	0.21±0.03
Potassium	108.34±1.48 mg
Calcium	11.53±0.22 mg
Total sugars	10.78±0.05
Vitamin C	13.81±0.26 mg
Vitamin B2	28.37±0.12 µg

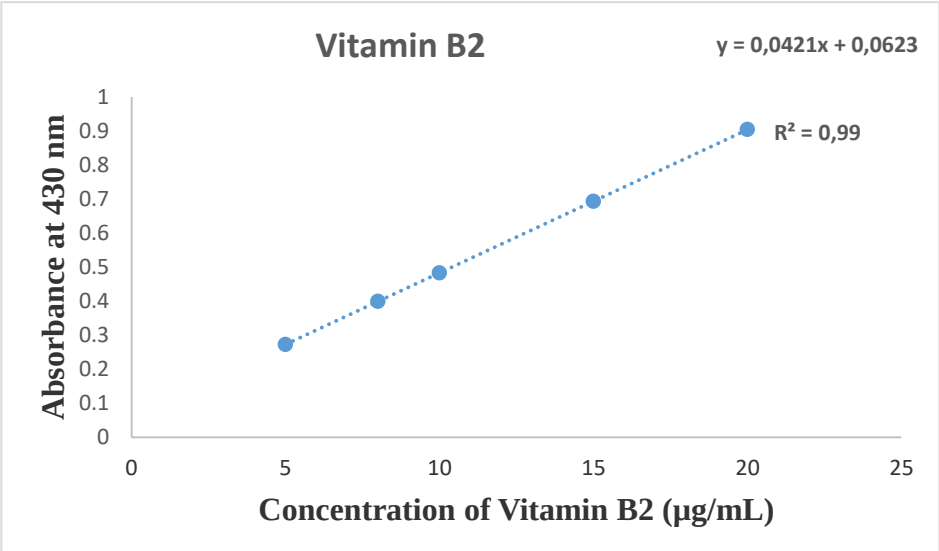

Fig. 2: Calibration curve for vitamin B2 using linear regression.

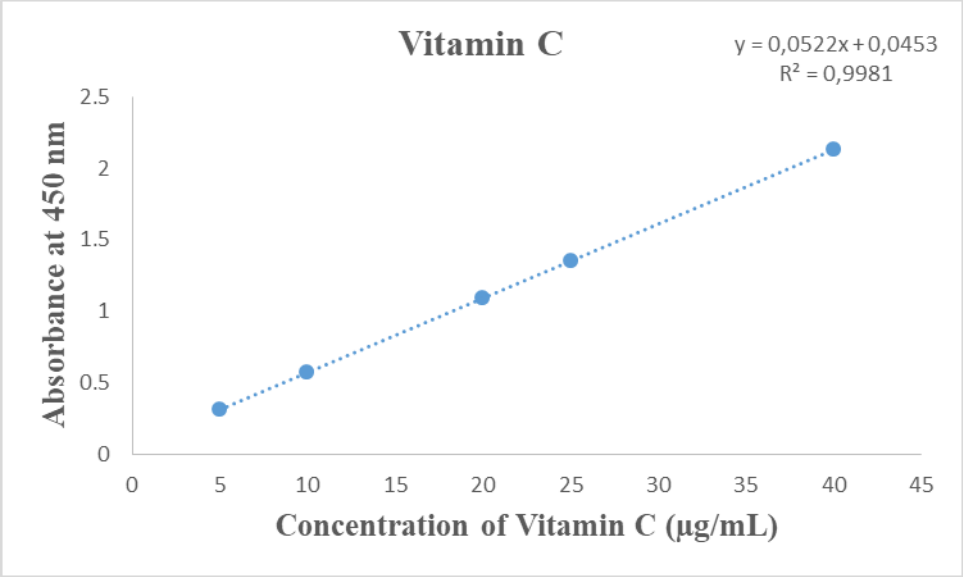

Fig 3: Calibration curve for vitamin C using linear regression.

The figures above show these calibration curves. The R^2 values obtained are 0.9993 and 0.9981 for vitamins B2 and C respectively, and are close to 1, indicating that there is a very good correlation between the concentrations used and the responses obtained. The absorbances measured at the respective wavelengths for each vitamin were plotted, and the quantities of vitamins were calculated and expressed as mass ratios. The values obtained are shown in Table 2 above.

Vitamin C is the most abundant vitamin in pineapple fruit. According to research by Aprifel (2019), 100 g of fresh pineapple of the 'Cayenne lisse' variety provides 46.1 mg of vitamin C. This result is significantly higher than the amount of vitamin C (13.81 mg) obtained from the 'Baronne' variety studied and grown in Kindia. These results are consistent with those reported by Inada et al. (2015), which confirm that pineapple is a recognised source of vitamin C amongst tropical fruits. The vitamin C in pineapple also contributes, in combination with bromelain, to the documented anti-inflammatory activity of this fruit.

Riboflavin (B2) is present in pineapple at a concentration of 0.031 mg/100 g (Lobo & Paull, 2017). These vitamins collectively contribute to the proper functioning of energy and nervous system metabolism. Riboflavin has been studied in particular by Mohd Noor et al. (2019), who report that the highest content is found in the Kew cultivar, highlighting varietal heterogeneity for this vitamin. Pineapples therefore do indeed contain vitamin B2, as does the 'Baronne de Kindia' variety, even though the content is low (28.37 µg) compared with vitamin C.

Water content is one of the most fundamental physico-chemical parameters for characterising the quality of fresh fruit, as it influences texture, shelf life and nutritional value. In fresh pineapple, water constitutes the largest fraction of the proximate composition. According to data reported by Lobo and Paull (2017), the average value is 86.45 g per 100 g of fresh fruit, which is close to the value found in Baronne de Kindia pineapples. This high moisture content gives pineapples their refreshing properties and contributes to their low energy content (Aprifel, 2019; Creapharma, 2023).

Ash content is an indirect indicator of the fruit's overall mineral content. In fresh pineapple fruit, the ash content is generally low, ranging between 0.20 % and 0.50 % of fresh weight, depending on the study. In our study, the total ash content was 0.21 ± 0.03 per cent, which is lower than that found by Lobo and Paull (2017), who reported an average

value of 0.37 per cent per 100 g of fresh fruit. The ash content observed in the whole fruit reflects the presence of macronutrients such as potassium, calcium, magnesium and phosphorus (Mohd et al., 2020).

Potassium is the most abundant mineral, with 108.34 mg per 100 g of pineapple fruit. This value is lower than those cited in the literature, which report average contents of 140 to 151.5 mg per 100 g of fresh fruit (Aprifel, 2019; Lobo & Paull, 2017). Similarly, Mohd et al. (2019) report potassium contents of 139.9 to 156.1 mg/100 g for different pineapple varieties. Calcium is approximately 13 mg/100 g according to the study by Lobo & Paull (2017), which is higher than the 11.53 mg content we found in the Baronne variety of Kindia.

The total sugar content of fresh pineapple is 9 to 10 g, depending on the source (Lobo & Paull, 2017). The pineapple of Kindia has a slightly higher sugar content, which is thought to be due to the various sugars it contains in addition to the better-known sugars such as glucose, sucrose and fructose. The sugar content changes dynamically as the fruit develops. Zhang et al. (2012) demonstrated that the accumulation of sucrose in pineapple flesh is regulated by key enzymes involved in carbohydrate metabolism. This accounts for variations in sugar content between seasons and production areas (Dorey et al., 2016).

3.3. Polyphenol and flavonoid content

The total polyphenol and flavonoid contents are calculated on the basis of the calibration curves for gallic acid and quercetin respectively (Fig. 4 and 5).

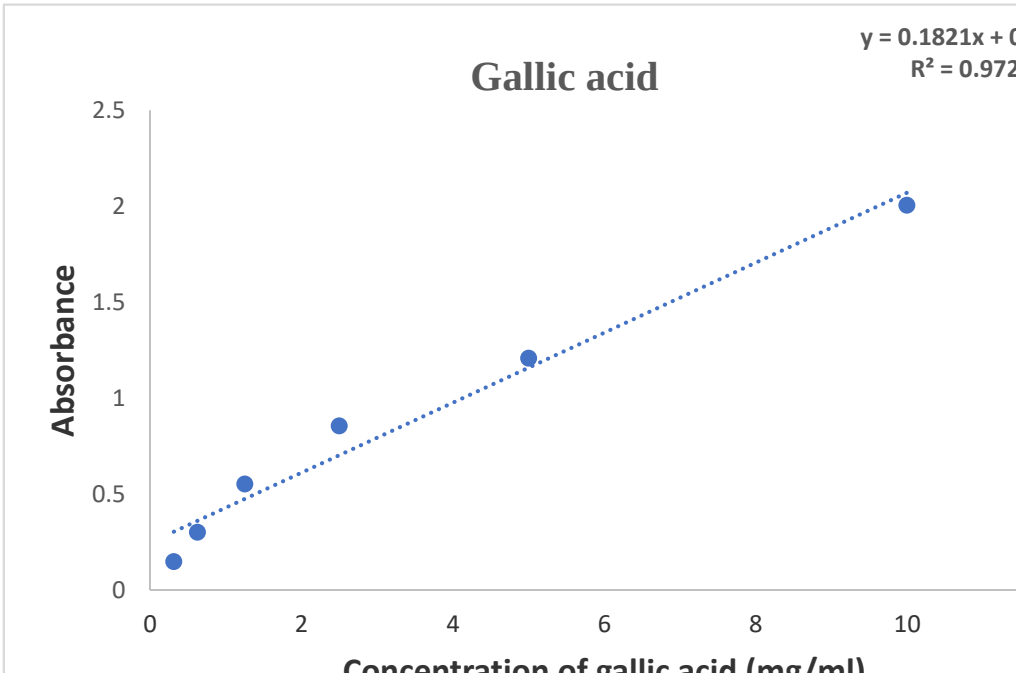

Fig 4: Calibration curve for gallic acid for the determination of polyphenols.

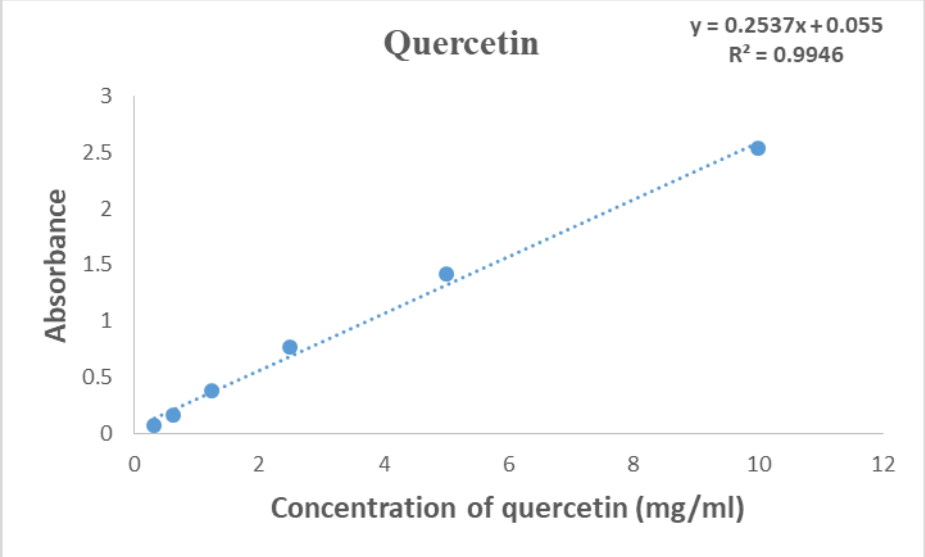

Fig. 5 : Calibration curve for quercetin for the determination of flavonoids.

The calculated values for total phenols and total flavonoids are 23.05±0.04 mg/g gallic acid equivalent and 11.26±0.06 mg/g quercetin equivalent, respectively. Ozioko et al. (2022) demonstrated that the presence of flavonoids and phenolic compounds confers antioxidant activity on the sample containing them. This finding reinforces the finding regarding the high vitamin C content of 'Baronne' pineapple fruit, as vitamin C is a benchmark antioxidant. The presence of flavonoids would explain the yellowish colour of the pineapple pulp, given that colours are partly due to plant pigments. The presence of these secondary metabolites also suggests that the pineapple studied may possess anti-inflammatory properties inherent to these chemical groups.

3.4. Microbiological quality

The total aerobic mesophilic flora count on the pineapple fruits analysed was 3.10^3 / g. The mould and yeast count was 108/g. These values comply with WHO standards (< 10^5/g). Yeasts and moulds are the dominant microorganisms in the natural microflora of fresh and cut pineapple. These results are consistent with the findings of Barth et al. (2009), who identified yeasts in pineapple juices and nectars. Similar results were also obtained by Sankhon et al. (2023) on various varieties of pineapple grown in Guinea.

Studies conducted in West Africa, notably in Benin, have examined the microbiological quality of pineapple-based beverages. Anago et al. (2021) assessed blends of pineapple, orange and carrot juices produced in different proportions. The microbiological results revealed a complete absence of thermotolerant coliforms, Escherichia coli and sulphite-reducing bacteria in all the samples tested, indicating good hygiene conditions during production. However, yeasts and moulds were present in all samples; their presence was attributed to the osmophilic nature of the sugary matrices analysed (Anago et al., 2021).

These results are consistent with those obtained by Agbangnan et al. (2016) when evaluating artisanal vinegars made from Ananas comosus in Benin, which contained no pathogenic bacteria and met the applicable ISO standards. The total aerobic mesophilic flora count (TAMFC), although detectable, remained within acceptable limits, confirming the feasibility of pineapple processing under controlled hygienic conditions.

CONCLUSION

The Baronne pineapple of Foulayah is characterised by its sugar content, moderate acidity and high vitamin and mineral content, and ranks amongst the finest fruit juices. The variability in the levels of the analysed parameters is linked to the soil's nutrient content, fertilisation practices and local climatic conditions. From a microbiological perspective, the results we have obtained clearly demonstrate the sanitary quality of the 'Baronne de Foulayah' pineapple, which has recently been cultivated in Foulayah. This microbiological quality is primarily due to adherence to good hygiene practices during harvesting and processing. The higher water content allows this study to be taken further by developing modern drying techniques to preserve the 'Baronne' pineapple from Foulayah, thereby helping to reduce post-harvest losses and contributing to the resilience of this promising sector in Guinea.

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AUTHORS' CONTRIBUTIONS

All the authors' participle in writing, giving feedback on this manuscript, have read and approved the final manuscript.

COMPETING INTERESTS

The authors declare that they have no competing interests.

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