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Viscosity Study of Mucilages Extracted from *Abelmoschus esculentus, Beilschmiedia mannii*, *Corchorus olitorius* and *Irvingia gabonensis* from Côte d'Ivoire

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The present work evaluates some rheological characteristics of mucilages of selected mucilaginous food plants from the Ivorian flora.
Study Design: Mucilage food plants edible parts were dried, mucilage were extracted and viscosity parameters analyzed.
Place and Duration of Study: The study was conducted in Laboratory of Biochemistry and Food Sciences, Biosciences Unit, at Felix Houphouet-Boigny University between January and December 2014.
Methodology: The study was carried out on fruits of *A. esculentus* (okra), *B. mannii* (sran), *I.*

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gabonensis (kplé) and leaves of *C. olitorius* (kplala) collected. The mucilage of different plants has been extracted by optimization methods. Then, the effects of pH, temperature, NaCl, KOH and concentration on mucilages viscosity have been studied.

Results: After extraction of the mucilages by appropriate methods, extraction yields and hydration capacity were determined. The mucilage contents of *B. mannii*, *I. gabonensis*, *A. esculentus* and *C. olitorius* were respectively 63.00 ± 2.69%, 56.34 ± 5.44%, 34.86 ± 5.27% and 25.81 ± 4.13%. Scanning electron microscope (SEM) observations of the mucilages have showed varying forms. Their viscosity was determined under the influence of mucilage concentration, pH and temperature, as well as NaCl and KOH concentrations. The mucilage concentration, pH and temperature, as well as NaCl and KOH concentrations significantly differentiate the viscosity of the solutions ($P < 0.001$). The increase in mucilage concentration (0 to 1%) and pH (3 to 8) increased the viscosity (0 to 801.93 ± 15.90 cP and 10.23 ± 0.70 cP to 574.60 respectively. On the other hand the elevation of the contents in NaCl of 0 to 1% (m/v) generated a decrease of the viscosity of the mucilaginous solutions of 535.00±24.53 to 69.70±2.95 cP. With KOH, concentrations of 0 to 0.4% (m/v) increased the viscosity of the mucilages from 100.00 ± 12.23 to 673.00 ± 9.92 cP, while contents from 0.4 to 1% reduced it from 673.00 ± 9.92 to 72.60 ± 13.39 cP. The heating of the mucilages from 20 to 120°C drastically reduced their viscosity of 546.20 ± 7.37 to 44.40 ± 4.07 cP, however, retrogression produced the opposite effect.

Conclusion: *B. mannii* mucilage exhibited a higher viscosity than other mucilage samples relative to factors Tests, with the exception of temperature.

Keywords: Mucilage; mucilaginous food plant; viscosity; Côte d'Ivoire.

1. INTRODUCTION

Mucilaginous food plants (MFPs) are part of a large group of plant species known as non-woody forest plants. These plants contribute significantly to the diet of populations by bringing most essential nutrients. Indeed, MFPs are important sources of carbohydrates, lipids, proteins, vitamins and essential minerals [1,2]. The consumption of MFPs varies from region to region. However, *Abelmoschus esculentus* (okra), *Corchorus olitorius* (kplala), *Irvingia gabonensis* (kplé) and fruit of *Beilschmiedia mannii* (sran) are among the species commonly consumed by populations [3]. Regarding the antioxidant and lipoperoxidation inhibiting effects related to *Abelmoschus esculentus*, *Corchorus olitorius*, supplementation [4,5,6] which adds to previous studies indicating functional food intake as a promising tool to contrast the burden of oxidative stress during aging and neurodegenerative diseases [7,8]. Okra has very high nutritional value for various nutrients [9,10]. It is consumed in the form of porridge, frying or soup throughout the world, with a yearly production estimated to 120000 tons [11]. The leaves of *C. olitorius* or kplala (Ivorian local name) are consumed in the form of soup characterized by a particularly glutinous texture. These leaves are rich in magnesium, iron and vitamins. They do not present anti-nutritional redhibitory factors [12,13]. With the kernels of *I. gabonensis* and the fruits of *B. mannii*, respectively called kplé and sran in Côte d'Ivoire, interesting nutritive properties are recorded [14, 15,16].

MFPs also contain mucilages which probably assume a multitude of physiological functions in plants. It is found in rhizomes, roots and seed endosperms, where it may act primarily as energy reserves [17], foliar mucilages also play a role in wound responses [18], plant host–pathogen interactions [19], water transport [20], and responses to abiotic stresses [21,22,23]. The high water-binding capacity of mucilage may offer plants the ability to resist physiological drought [18,21,24]. By acting as an apoplastic capacitor [25] mucilages can also enable leaves to maintain low water potential when soil water deficits develop [26]. that exhibit hunger-cutting properties and regulate blood glucose, blood pressure, cholesterol, and homeostasis [27,28]. Their consumption is generally based on their high mucilage content of 56% (*I. gabonensis*) and 25% (*C. olitorius*) [29]. Indeed, mucilage is a complex carbohydrate with a highly branched structure containing variable proportions of L-Arabinose, D-galactose, L-Rhamnose and D-xylose and galacturonic acid [30,31] which in the presence of water swells and forms a viscous substance.

The mucilaginous nature of these plants is the origin of the study of their rheological properties. This science indeed describes the flow, the

deformation and the rupture of a body under the effect of a constraint [32] and is characterized mainly by the viscosity, the elasticity and the plasticity [33]. According to [34], the variability observed in mucilage levels can be explained by extraction methods, variety, maturity stage of the analyzed parts, and environmental conditions. These factors, especially the environmental conditions, would not alter the viscosity of the extracted mucilages?

The numerous uses of mucilages in the fields as varied as agro-food, pharmaceuticals and cosmetics [35,36], would obviously involve the use of substances whose effects on viscosity deserve to be studied. Consequently, the present work consists in evaluating the viscosity of the mucilages according to the applied treatments.

2. MATERIALS AND METHODS

2.1 Plant Material and Extraction

The biological material consisted of the kernels of *Irvingia gabonensis* (kplé), the fruits of *Beilschmiedia mannii* (sran), the leaves of *Corchorus olitorius* (kplala) and the variety koto of *Abelmoschus esculentus* (okra). The plants have been authenticated by the Centre National de Floristique (CNF) of the University Felix HOUPHOUET-BOIGNY. Mucilaginous food plants have been collected in several regions of Côte d'Ivoire.

2.2 Processing to Obtain Dry Matter

The plant material was collected between January and December 2014 in different regions of Côte d'Ivoire. The fruits of *Irvingia* have been stocked several days then the seeds have been broke to isolate the fresh kernels. As for the fruits of *B. mannii*, they have been cut in small pieces (less than 5 mm of thickness) before drying. In return, the fruits of *A. esculentus* (okra) have been cut in gill, whereas the leaves of *C. olitorius* were sorted, cleaned and drained before being dried. After drying, plants parts collected have been reduced in powder with a grinder of Heavy Duty mark [29].

2.3 Mucilage Extraction

According to the method of mucilage extraction of Kolhe [37], the application of full factorial design was permitted to determine most significant factors. With these factors, a optimization of mucilage extraction has been done. Thus we obtained.

The powder of *I. gabonensis* kernels was delipidated with hexane and then macerated for 24 h in distilled water with a ratio of 1/50 (vegetable / water). The whole is filtered on a muslin cloth. The mucilage is collected, dried and ground and then stored in desiccators.

As for *B. mannii*, *C. olitorius*, *A. esculentus*, the powders are macerated in distilled water for 24 h with a ratio 1/50 (vegetable / water). The mixture is then boiled for 1 hour and filtered on a muslin cloth. The mucilage is collected, dried and ground and then stored in desiccators [29].

2.4 Qualitative Tests

Preliminary tests such as red ruthenium test, the Molisch test and the iodine test have been done to confirm the mucilaginous nature of substances obtained [38,39,40].

2.4.1 Red ruthenium test

This test is used to confirm the presence of mucilage. A small amount of dried mucilage powder has been mounted on a slide with a solution of ruthenium red and observed under a microscope

Pink color was developed

2.4.2 Molisch test

This test is used to confirm the presence of carbohydrate in the mucilage. 0.1 g of dried mucilage powder has been placed in a clean test tube. Then, two drops of the freshly prepared Molisch reagent were introduced. Finally, concentrated sulfuric acid has been added gradually to the side of the tube to form a layer above the aqueous solution.

Violet color was observed at the junction of two layers.

2.4.3 Iodine test

This test is used to confirm the presence or absence of starch in the mucilage. 0.1 g of dried mucilage powder has been added to 1 ml of iodine solution at 0.2% dye in a test tube and the mixture has been observed.

No color was developed in solution.

2.5 Photograph of Mucilages

2.5.1 Mineralization

The method of determination of ashes was already described [41] that consisted to incinerate a sample to 550°C until the obtaining of white ash. Thus, 5 g of dry matter has been introduced in a capsule of incineration. The capsule has been placed in muffle furnace (PYROLABO, France) and incinerated to 550°C during 24 h. After calcinations and cooling in desiccators, the white ashes have been collected for analysis.

2.5.2 Operative conditions of the energy dispersive spectrophotometer (EDS)

The apparatus used for minerals determination was an energy dispersive spectrophotometer coupled to scanning electron microscope (SEM). This device to variable pressure (SEM FEG Supra 40Vp Zeiss) was equipped of an X-ray detector (Oxford instruments) bound to a flat shape of EDS microanalyser (Inca cool dry, without liquid nitrogen) [42]. The operative conditions of the EDS-SEM were the following:

- Enlargement : 10x to 1000000x;
- Resolution : 2 nm;
- Variable voltage : 0.1 KeV à 30 KeV ;
- Acquirement of the elementary chemical composition: enlargement, 50x; borer diameter, 30 nm and 120 nm; borer energy, 20 KeV and 25 KeV; work distance (WD), 8.5 mm.

2.6 Determination of the Mucilages Hydration Capacity

The capacity of water absorption of mucilages has been valued according to method used by [43]. A trial hold of 0.5 g of powder of mucilage has been placed in a tube centrifuge. Then 10 ml of distilled water has been added and the whole has been homogenized vigorously during 2 minutes then centrifuged to 1000 tpm during 10 minutes. After withdrawal of the supernatant, the tube containing the sediment has been weighed and the mass of the hydrated mucilage permitted to calculate his capacity of hydration:

$$\text{Hydration capacity} = (M_2 - M_1)/M_2$$

With M_1, mucilage dried weight (0.5 g); M_2, mucilage hydrated weight (g)

2.7 Factors Effect on Viscosity

The influences of the mucilage, NaCl and KOH concentrations, as well as the pH and the temperature on the mucilage viscosity were determined using a viscometer (Brookfield DV-II), with speed of 12 rpm, according to the method described by [44]. Viscosities were expressed in centipoise (cP).

2.7.1 Mucilage concentration

The effects of the mucilage concentration on the viscosity were studied 6 hours after dispersion of 0.2 g, 0.5 g, 0.8 g and 1 g of mucilage in 100 mL of distilled water at ambient temperature of 25°C.

2.7.2 pH

The influence of pH on the viscosity was determined after dispersion of 0.5 g of mucilage in 100 ml of buffer solutions having a pH range of 3, 5, 6, 7 and 8 at room temperature of 25°C. The contact time of the mucilages was 6 hours, after that viscosity was measured

2.7.3 Temperature

A sample of 0.5 g of mucilage was dissolved in 100 mL of distilled water. After 6 hours of maceration, the solutions were brought to a temperature range of 20 to 120°C in a thermostated water bath. The incubation time was 10 minutes for each temperature. Then, the absolute viscosity was measured. In order to study the reversibility of these mucilages opposite the temperature, the solutions were brought to 120°C, after the temperature rise, then they were gradually cooled to 20°C and the change in viscosity was also measured.

2.7.4 NaCl or KOH concentrations

The effects of salt (NaCl) and potash (KOH) concentrations on viscosity were studied 6 hours after dispersion of 0.5 g of mucilage in 100 mL of saline or alkaline solution at 0%, 0.2%, 0.4%, 0.6%, 0.8% and 1% (w/v) concentration at room temperature of 25°C.

2.8 Statistical Analysis

The statistical processing of the data consisted of an analysis of variance (ANOVA) with a classification criterion using the SPSS software (SPSS 16.0 for Windows, SPSS Inc.). Means

were compared by the Newman Keuls test at the 5% significance level.

3. RESULTS

3.1 Results of Extraction of Mucilages

The mucilage contents differentiate ($p < 0.001$) the mucilaginous food plants retained. The different mucilages extracted are shown in Fig. 1. *B. mannii* (63.00 ± 2.69%) and *I. gabonensis* (56.34 ± 5.44%) provide the highest mucilage contents, unlike *A. esculentus* (34.86 ± 5.27%) and *C. olitorius* (25.81 ± 4.13%) (Table 1).

3.2 Mucilage Confirmation Tests

Preliminary mucilage confirmation tests (Molisch test, ruthenium red test and iodine test) are all positive with the different mucilages (Table 2).

The results of different tests showed the presence of mucilage, carbohydrate and polysaccharides.

Table 1. Mucilages content

Plants	Mucilage content (g/100gMS)
I. gabonensis	56.34±5.44[b]
B. mannii	63.00±2.69[a]
A. esculentus	34.86±5.27[c]
C. olitorius	25.81±4.13[d]
F	**113.70**
P-value	**<0.001**

3.3 Images in SEM/EDS

Scanning electron microscopy (SEM/EDS) photographs reveal that *A. esculentus* mucilage has an irregular planar structure with particles (A), followed by *B. mannii* showing an ovoid-shaped structure (B). The mucilage of *C. olitorius* is composed of concretions with fine particles (C), while *I. gabonensis* consists of smooth microplates with regular contours (D) (Fig 2).

Table 2. Preliminarily tests of confirmation

Plants	Molisch test	Ruthénium red test	Iodine test
I. gabonensis	+	+	+
B. mannii	+	+	+
A. esculentus	+	+	+
C. olitorius	+	+	+

3.4 Hydration Capacity of Mucilages

B. mannii mucilage was hydrated (519.52 ± 22.19%) more than that obtained from the other three plants studied. Fig 3 shows that *C. olitorius* mucilage provides the lowest hydration capacity (257.39 ± 8.64%).

3.5 Effects of Mucilage Concentrations and pH on Viscosity

Mucilage concentrations Increasing from 0% to 1% (m/v) led to a significant increase ($p < 0.001$) of viscosity of their aqueous solution from 0 cP to 801.93 ± 15.90 cP (*B. mannii*), 515.50 ± 14.50 cP (*I. gabonensis*), 317.50 ± 7.49 cP (*A. esculentus*) and 235.00 ± 5.78 cP (*C. olitorius*) (Fig. 4).

Similarly, an increase in the pH of the mucilage solutions, from 3 to 8, generates a significant increase in viscosity ($p < 0.001$). The values of 21.00 ± 1.15 cP (*B. mannii*), 14.40 ± 0.62 cP (*I. gabonensis*), 11.70 ± 0.85 cP (*A. esculentus*) and 10.23 ± 0.70 cP (*C. olitorius*) obtained at pH 3 fluctuated respectively at 551.50 ± 13.51 cP, 356.20 ± 12.52 cP, 180.80 ± 8.32 cP and 93.50 ± 7.53 cP Between pH 6 and 8 (Fig. 5).

3.6 Effect of Heating and Cooling on Mucilages Viscosity

The increase in temperature from 20°C to 120°C leads to a decrease in the viscosity of the mucilages. The viscosities of 546.20 ± 7.37 cP, 299.10 ± 11.17 cP, 168.10 ± 8.74 cP and 118.40 ± 8.20 cP provided at 20°C by *B. mannii*, *I. Gabonensis*, *A. esculentus* and *C. olitorius*, respectively, fell to 373.30 ± 13.02 cP, 167.40 ± 11.17 cP, 96.60 ± 4.31 cP and 44.40 ± 4.07 cP at 120°C. On the other hand, the retrogression of the temperature (from 120°C to 20°C) after heating the mucilages produces the opposite effect. The mucilages became viscous again, with values increasing at 373.30 ± 7.10 cP (*B. mannii*), 167.40 ± 11.17 cP (*I. gabonensis*), 96.60 ± 4.31 cP (*A. esculentus*) and 44.40 ± 4.07 cP (*C. olitorius*) to 493.60 ± 14.47 cP, 275.00 ± 9.18 cP, 155.20 ± 4.82 cP and 97.50 ± 4.51 CP, respectively (Fig. 6). However, at each temperature, the viscosities obtained during cooling remain lower than those recorded during heating of the mucilages, with losses of 7.67% (*A. esculentus*), 8.05% (*I. gabonensis*), 9, 63% (*B. mannii*) and 17.65% (*C. olitorius*).

3.7 Influence of NaCl and KOH Concentrations on Mucilage Viscosity

In the absence of NaCl, the mucilage solutions had viscosities of 535.00 ± 24.53 cP, 281.50 ±

17.78 cP, 165.00 ± 13.79 cP and 103.00 ± 9.17 cP respectively For *B. mannii*, *I. gabonensis*, *A. esculentus* and *C. olitorius*. On the other hand, the continuous addition of salt significantly reduced ($p < 0.001$), these viscosities that fall to 388.00 ± 22.61 cP (*B. mannii),* 222.70 ± 13.98 cP (*I. gabonensis*), 99.40 ± 9.40 cP (*A. esculentus*) and 69.70 ± 2.95 cP (*C. olitorius*) at 1% NaCl (Fig. 7).

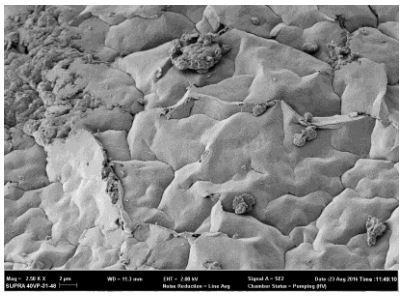
A: Mucilage of *A. esculentus* (koto)

B : Mucilage of *B. mannii*

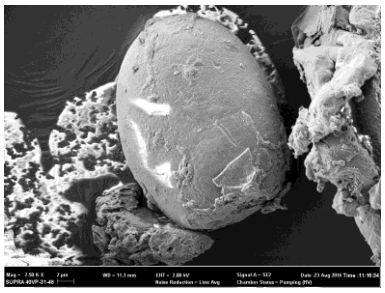
C : Mucilage of *C. olitorius*

D : Mucilage of *I. gabonensis*

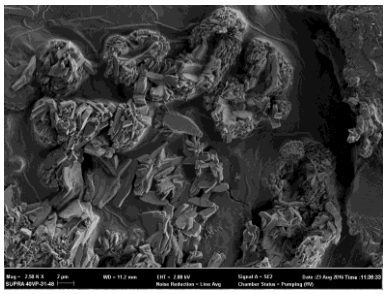
Fig. 1. Powder of mucilage



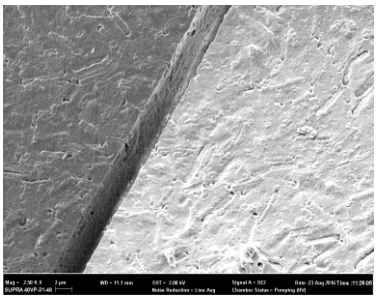
A: Mucilage of *A. esculentus* (koto)



B: Mucilage of *B. mannii*



C: Mucilage of *C. olitorius*



D : Mucilage of *I. gabonensis*

Fig. 2. Photo of mucilages by SEM/EDS

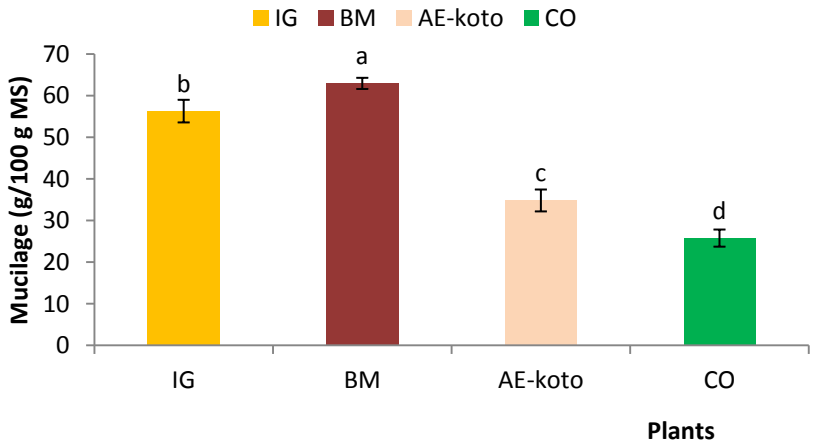


Fig. 3. Hydration capacity of mucilages

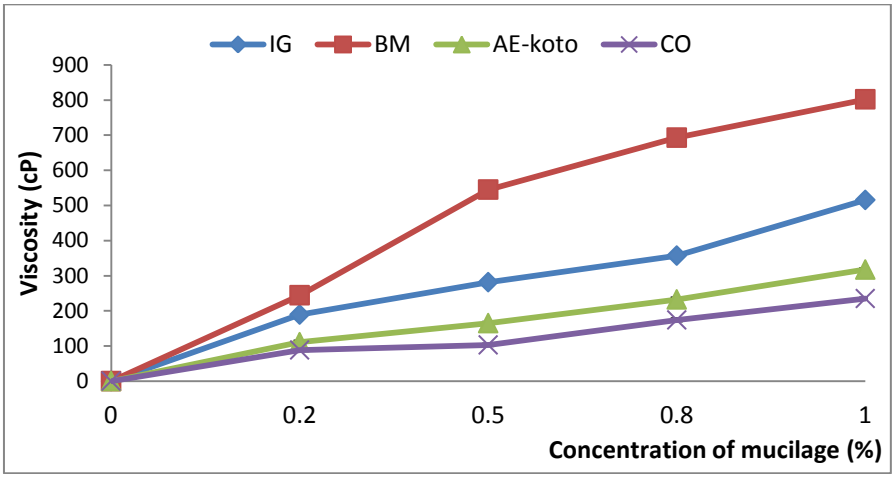


Fig. 4. Effect of concentration on viscosities curves of aqueous solutions of mucilages

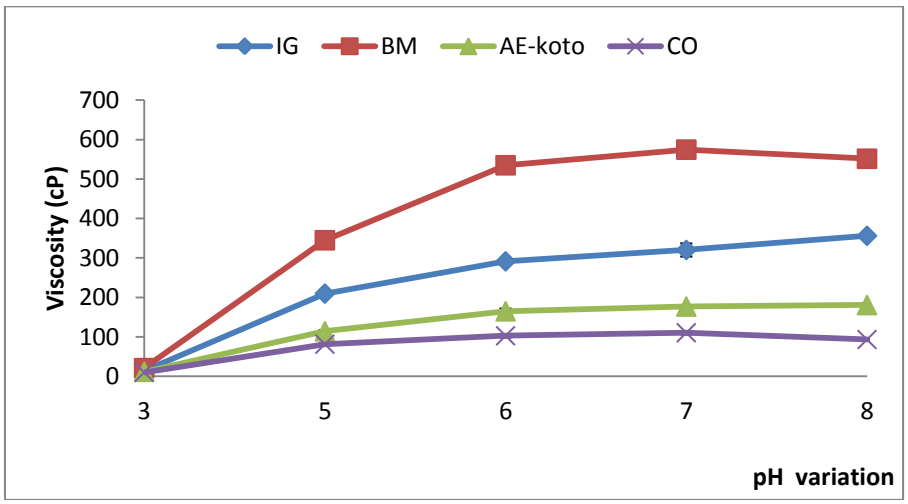


Fig. 5. Viscosity curves of aqueous solutions of mucilages based on MFPs studied according to the pH

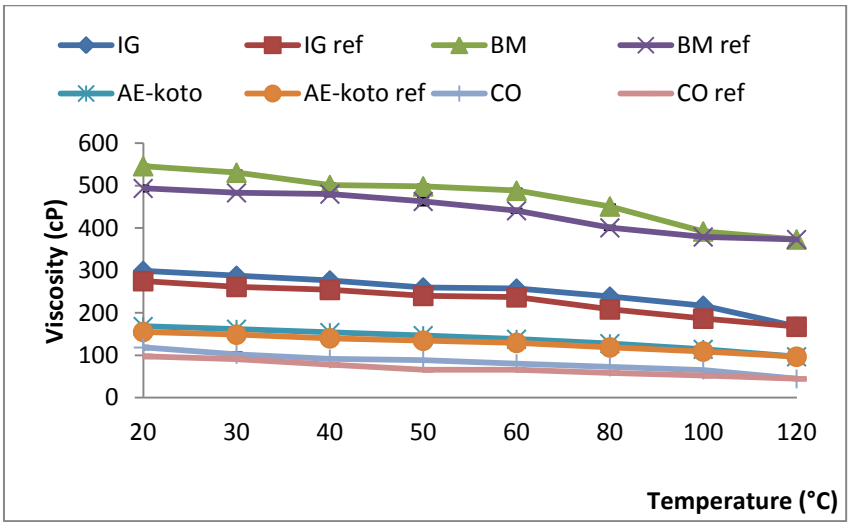


Fig. 6. Viscosity curves of aqueous solutions of mucilages based on MFPs studied during the elevation and the cooling (ref) of the temperature

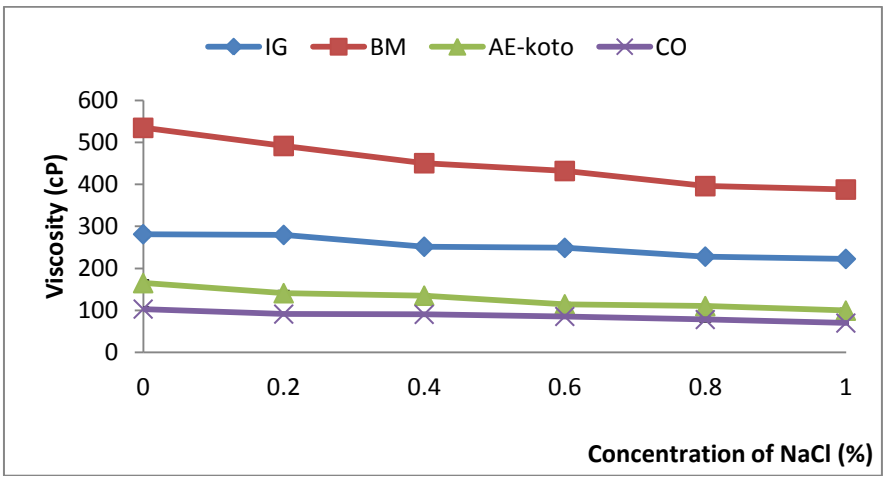


Fig. 7. Viscosity curves of aqueous solutions of mucilages based on MFPs studied according to the concentration in NaCl

Concerning KOH, the addition of small amounts (0% to 0.4%) allows an increase in the viscosity with values which go from 535.00 ± 11.90 to 673.00 ± 9.92 cP (*B. mannii*), 281.50 ± 11.27 to 344.00 ± 7.36 cP (*I. gabonensis*), 165.00 ± 15.52 to 214.10 ± 7.99 cP (*A. esculentus*) and from 100.00 ± 12.23 to 150.70 ± 10.05 cP (*C. olitorius*). On the other hand, high KOH contents (> 0.4%) induce a progressive decrease in viscosities to respective values of 521.30 ± 11.42 cP, 255.70 ± 6.10 cP, 163.10 ± 11.60 cP and 72.60 ± 13.39 cP at 1% KOH (Fig. 8).

Moreover, during these evolutions, the highest viscosities are recorded in the mucilage of the *B. mannii*, while *C. olitorius* provides the lowest values.

4. DISCUSSION

Hydrocolloids have been used in traditional cooking for decades to thicken and give flavor to sauces before being used as industrial gums [45]. Mucilages extracted reactions with ruthenium red, Molisch and iodine tests showed the presence of mucilage, carbohydrate and the absence of starch respectively, thus confirming the mucilaginous nature of extracted substances [46]. The edible parts of plants with high mucilage contents are represented by *B. mannii* (63.00%) and *I. gabonensis* (56.34%) followed by *A. esculentus* (34.86%) and *C. olitorius* (25.81%). similar results have been obtained on *Bombax costatum* (45%) and *Grewia venusta* (20%) [47] and *B. costatum* (46.5%) and *Cissus populnea (29.8%)* [48]. *Much work has been*

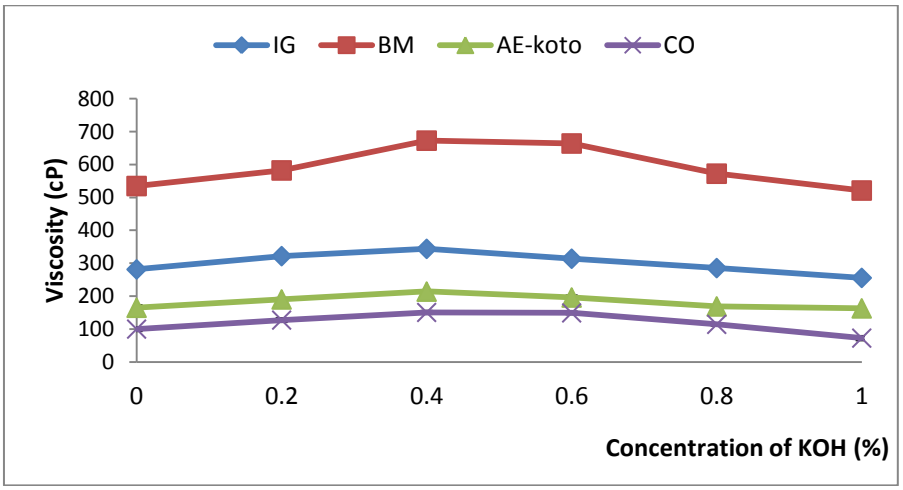


Fig. 8. Viscosity curves of aqueous solutions of mucilages based on MFPs studied according to the concentration in KOH

done on okra, including [49], which reported a very high yield of 57%, when [50] were able to extract only 9.5% of mucilage. At the same time, our results on *C. olitorius* are close to the 29.18% revealed by [44]. According to [34] this variability observed in the levels of mucilage could be explained by the extraction methods, the variety, the stage of maturity of the parts analyzed, as well as the environmental conditions.

These mucilages are characterized by their high water absorbency and swell to form viscous substances due to their high content of polysaccharides [31]. The mucilages based on *B. mannii*, *C. olitorius*, *I. gabonensis* and *A. esculentus* provided hydration capacities between 257.39 ± 8.64% and 519.52 ± 22.19%. Several authors have reported similar observations. Thus [51] reported 157.09% hydration at mucilages based *Ocimum canum* when [52] received 461.87% hydration from mucilage base on leaves of cactus. According to [53], the hydration mechanism is very fast in the first minutes, but drops after 2 hours due to the state of saturation. This property of mucilages is widely used in the food industry to combat syneresis. Indeed, some substances release water during storage; which is detrimental to the quality of the products.

Tests for the influence of mucilage concentration, temperature, pH, salt and potash on viscosity showed that these factors significantly altered this property. Similar results have been obtained by several authors [54,55]. The concentrations of mucilages used in our study proved very important. Indeed, an increase in the mucilage concentration also leads to an increase in the viscosity. This interaction between concentration and viscosity has been observed in previous work [56,57]. The different viscosities of the mucilages obtained are greater than the 40 cP to 250 cP provided by the mucilages of *Dicerocaryum zangueharium* with concentrations of 0 and 1.6% [57]. They also surpass the 120 cP resulting from 12% mucilages of *Grevillea robusta* [58] and the 22.60 cP obtained with 1% *Acacia senagal* gums [59]. On the other hand, the viscosities of 2500 cP with 0.5% mucilages of *Salvia hispanica* [60] and 10000 cP for 1% Guar gums [61] are far superior to ours.

The pH variation of 3 to 8 generated an increase of the viscosity of the different mucilages with a maximum viscosity between pH 6 and 8. This pH impact on hydrocolloids was also emphasized by [62] and [63]. In the same way, [64] obtained viscosities of 195.7 cP with *Basella alba* mucilages at pH 5.3 and their results are similar to those obtained with okra and *C. olitorius* mucilages. However, higher viscosities (247.34 cP) have been observed at pH 6.7 by [65] on mucilages of okra. The increase of the viscosity with the pH could be due to the presence of uronic acids in the hydrocolloids, capable of conferring polyelectrolytic behavior in solution. Indeed, the increase in pH induces the ionization of the macromolecules. Thus, their charge density in carboxyl groups increases, creating an electroviscous effect [66,67].

The influence of temperature on the viscosity of the mucilages showed a general decline. A similar observation has been made by [68] on the gums of *Triumfetta cordifolia* and *Bridelia thermifolia* with viscosities of 322 to 87 cP and 90

to 36 cP respectively. According to [69], raising the temperature of the solution could increase the energy dissipation of the molecules, resulting in a decrease in intermolecular interactions and consequently in the activation energy of flow. However, certain stability was observed in the viscosities of *C. olitorius* mucilages and *Terminalia catappa* gums between 40°C to 70°C respectively [70] and 25°C to 60°C [55]. In our work, the temperature was tested up to 120°C, close to the culinary conditions practiced by African households in general. Subsequently, the cooling of the mucilage solutions by temperature retrogression (120°C to 20°C) allowed a revival of viscosity with a loss of 7.67% to 17.65% relative to the original values. [71] obtained comparable results on mucilages of okra and baobab leaves with temperatures between 100 and 20°C. Thermal loss of viscosity would result from the denaturation of the protein residues contained in the mucilages [72]. However, the increase in viscosity of the mucilaginous masses in cooling after heating could be dependent on the polysaccharides, which are essential to the architecture of the mucilages, whose degradation is irreversible only beyond 200°C [73].

Our work also revealed significant losses of viscosity related to the large saline concentrations, corroborating the observations reported by [57] on mucilage *D. zangueharium*. NaCl would promote contraction of polysaccharide molecules and cause their low rheological activity [66]. In contrast, potash would promote this activity at doses below 0.4%. This reinforces current practices in some households where alkaline substances such as potash or carbonates are used to increase the viscosity of sauces [71].

The different aspects of mucilages studied to know the nourishing, sensory and rheology aspect show an interaction between these. Indeed, during the studies of sensory analysis, the choice of the panelists especially carried itself on the recipes references in relation to the recipes based on mucilages those exits of *B. mannii* and *I. gabonensis*. This choice seems to explain itself by two facts: first the recipes references kept the totality of their nourishing components, and then *B. mannii* and *I. gabonensis* are the plants having expressed the strongest viscosities.

5. CONCLUSION

The plants *B. mannii* and *I. gabonensis* are given the best yields of mucilage. The study undertaken showed high water absorption of the mucilages of MFPs. This absorption is more marked with mucilages based on *B. mannii* and *I. gabonensis*. Depending on the mucilage concentrations, as well as the salt and potassium contents, also the pH and the temperature, the mucilage solutions studied record gains or losses in viscosity. The impact of external factors on the viscosity of the various mucilages could guide the users of these substances on suitable products for their activity.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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