Study of the nutritional quality and therapeutic virtues of mosaic virus Infected and healthy cassava leaves in theCentral African Republic.

Abstract

Research Problem: Cassava leaves play an important role in the diet of the Central African population. Several studies have investigate the composition in nutrients of cassava leaves but only few study focused on the impact of the cassava mosaic virus disease, the main threat of the cassava production in sub-Saharan Africa, on the nutritional value of infected cassava leaves. The objective of this work is to determine the content of nutritionaland anti-nutritional compounds in cassava leaves infected by the mosaic virus and healthy leaves.

Material and Methods:The study was performed on two cassava varieties that are M66033 (susceptible to be infected by the mosaic virus) and Togo or TMS66 (resistant to the virus) planted in the locality of Bangui, the Capital of the Central African Republic. Cassava leaves were collected 3 months after planting, separated according to the mosaic severity symptoms (0 to 5) and kept at 4°C in a fridge. Biochemical analyses were performed on leaves for the determination of fiber, protein, lipid and carbohydrate contents as well as antioxidant contents.

Result: The results showed that, the dietary fiber content is 44% in healthy leaves, it decreases from 42% to 26% in cassava leaves infected with mosaic virus. Protein content was 4% in the infected cassava leaf samples and 3% in the healthy cassava leaves. Lipid content decreases from 7% to 2% in mosaic-infected cassava leaves, it is 5% in healthy leaves. The carbohydrate content is 59% in mosaic-infected leaves and 43% in healthy leaves. The polyphenol content is 30 mgeq GA/ g in cassava leaves with mosaic symptoms and 28 mgeq GA/ g in healthy leaves. Flavonoid content decreases from 6 10-2 mgeq Q/ g to 0.510-2 mgeq Q/ g in cassava leaves with the mosaic symptom. Tannin content decreases from 6 10-2 to 0 mgeq cat/ g in mosaicinfected cassava leaves. Tannin content is 210-2 mgeq cat/ g in healthy leaves. -The defense mechanism developed by cassava plants infected with mosaic virus has an effect on the synthesis of biochemical compounds, fibers, proteins, lipids, carbohydrates, polyphenols, Flavonoids and tannins. These results suggest thatcassava leaves infected by mosaic virus are an excellent foodfor consumer health.

Key words:Leaf, cassava, virus, biochemical, compounds,foodstuf

Introduction

Cassava is a vital food resource for over 800 million people in tropical Africa. It contributes to food security because of its high nutritional and economic value. Also, cassava is grown in about 40 countries in Africa, with an annual production of 54,831,000 tons[8] Leafy vegetables play an important role in the diets of all populations of the world by providing the essential part of nutritional and medicinal needs [6] . They are effective against anemia, diabetes, constipation and high blood pressure due to their composition. More than 275 species of leafy vegetables are counted including tropical leafy vegetables [11]. Cassava leaves are a staple food for many

African communities. Some of them consume them every day. These are advised in the diet of people living with HIV/AIDS.

From a nutritional point of view, these vegetables contain 17-34% crude protein and 16-26% fiber by dry weight[12]. Due to the presence of cyanogenicglucosides (linamarin and lotaustralin) whose concentration varies from 1000 to mg/kg dry weight, cassava leaves are always previously treated by blanching or steaming to ensure the elimination of these cyanogenic compounds [12]. The toxicity of cassava leaves and the anti-nutrients limit their food consumption.

Cassava mosaic is a major threat to cassava production and food security of the population. The loss of production due to this yield decline would be linked, from a physiological point of view, to the reduction of leaf area, also to the fall in chlorophyll levels pigment responsible for photosynthesis [20]. Constraints related to production and yield reductions of cassava tuberized roots do not impact the food and therapeutic uses of cassava leaves infected by the mosaic virus .[15]

In the Central African Republic, part of the Central African population shows a preference for cassava leaves with mosaic symptoms [20]. Research should be considered to investigate the biochemical compounds of cassava leaves infected with mosaic. Although various studies have been carried out on the nutrient compositions of cassava leaves, while, these have not incorporated aspects related to the impact, of mosaic virus on the nutritional value of cassava leaves.It would be interesting to explore compounds nutritionally and therapeutically useful in cassava leaves infected by the mosaic virus.Thus, the present work aims to determine nutrients, non-nutrients and antioxidant contents in mosaic-infected and healthy cassava leaves.

Material and methods

Installation and monitoring of the experimental plot

Cassava cuttings of the local variety Six Months or M66033 and the Togo variety or TMS66 were collected at the research station of the Central African Institute of Agronomic Research (ICRA), and were used to set up an experimental plot at the University of Bangui to collect cassava leaves for analysis. The experimental design adopted for this study is non-statistical. Each elementary plot is 5 m long and 4 m wide, i.e. an area of 20 m2 with a total of 20 cuttings with a spacing of one meter between and on the rows. The establishment of the plot required clearing, plowing, staking and planting. This plot is set up on July 06, 2021. The first weeding to maintain the field was carried out after one month of planting, the others at regular intervals every two (2) months.

Collection of cassava leaves

Cassava leaf samples were collected in a cassava experimental plot at the University of Bangui from diseased and healthy plants. The samples were placed in A4 envelopes and sent to the Laboratory of Architecture, Analysis and Reactivities of Natural Substances (LARSEN) and many other samples were analyzed at the Laboratoire of hydro sciences Lavoisier at the University of Bangui. The cassava leaves collected were separated following the symptom severity index (SSI) ranking from 0 (no symptoms on leaves) to 5 (most affected leaves). The samples of the collected cassava leaves were divided as follows. The control consists of the leaves of the Togo or TMS66 cassava variety

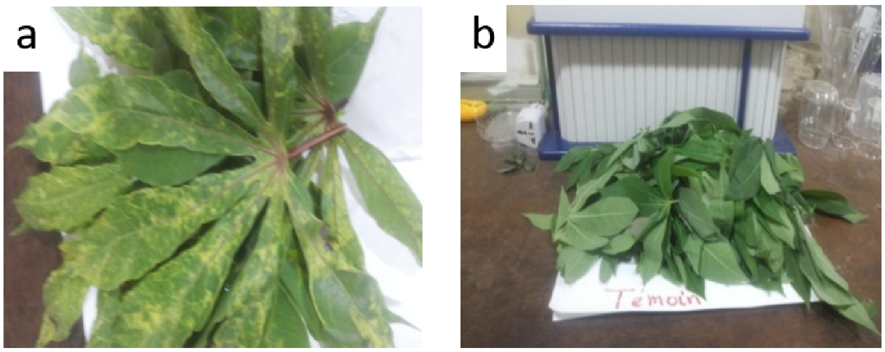

Figure 1. Cassava leaves infected (**a**) and no infected (**b**) by the mosaic virus. Infected leaves are characterized by the presence of yellow spots and foliage deformation.

Fiber content

The determination of the dietaryfiber content was done according to the method of [18] Two (2) grams of dried and ground sample were introduced into a flask and 50 mL of 0.25 N sulfuric acid was added. The resulting mixture was homogenized and boiled for 30 min under reflux refrigeration. After 30 min, 50 mL of 0.31 N NaOH was added to the contents and boiled again under reflux refrigerator for 30 min. The resulting extract was filtered through Whatman paper and the residue was washed several times with hot water until complete removal of alkali. The residue was dried in an oven at 105°C for 8 h. After cooling in a desiccator, the residue was weighed and then incinerated in an oven at 550°C for 3h. After cooling the ash obtained was weighed. The crude fiber content was given as percentage of sample mass as follows:

$$\text{Crude fiber (\%)} = = \frac{m1-me}{me} \text{x100}$$

Where *me*is the: mass (g) of the samplem_1; is the: mass (g) of the dried residue; $m_2$is the: mass (g) of the ash obtained.

Determination of the protein content

The crude protein content was determined from the determination of total nitrogen according to the method of Kjeldhal[2]   partially modified. It includes a mineralization phase followed by a distillation phase and a titration phase with sulfuric acid.For the mineralization phase, 1 g of dried and crushed leaves was taken in a mineralization matras to which were successively added a pinch of catalyst (selenium + potassium sulfate) and 100 ml of concentrated sulfuric acid. Mineralization was carried out at 250°C for 2 h in a BUCHI digester. After cooling the tube to room temperature, the mineralization was transferred to a 100 mL volumetric flask and made up to the mark with distilled water.

For the distillation phase, the ammonium ions are transformed into ammonia by passage in an alkaline medium. The (volatile) ammonia thus formed is carried away by water vapor (hydro distillation), the vapors, condensed by refrigeration, are collected in a sufficiently acid medium10 mL of 40% (w/v) NaOHwas added to 10 mL of mineralization and the mixture was placed in the distillation tank (Figure 2). The distillation cooler extension was then dipped into a beaker containing 20 mL boric acid spiked with a mixed indicator (methyl red+ bromocresol green). The distillation was carried out for 10 min. The distillate was then titrated with a 0.1 N sulfuric acid solution until the colorchange. From green to orange. A blank was performed under the same conditions as control. The rate of nitrogen was calculated as follow:

%Nitrogen = (Sulfuric acid volume×0, 007) / (sample mass).

The percentage of nitrogen obtained is multiplied by 6.25 to get the total protein content.

Figure 2:Dosing of the distillate and turning of the solution

Determination of the lipid content

The lipid content was determined according to the method described by [1] then modified, using a magnetic extractor. 1g dried and ground sample was placed in a flask using 30 ml of cyclohexane. After 5 h the extract obtained was filtered and the solvent was recovered using a

VACUUBERAND rotavapor.The initially tared flask containing the oil was weighed to determine the oil mass. The lipid content is expressed as a percentageand calculated as follow:

$$\text{Th} = \frac{\text{m} x\, 100}{\text{m}_E} x 100$$

Where Th is the oil content expressed as a percentage (%); mis the mass of oil extracted after taring the extraction flask;m_E is the: sample mass (g) of crushed material subjected to extraction.

Determination of carbohydrate content

The total carbohydrates and energy value were determined according to the calculation method recommended by the [7], which takes into account the moisture, fat, protein and ash content on the one hand and the energy coefficients for leafy vegetables on the other.

Carbohydrate (% DM) = 100 - (P (% DM) + L (% DM) + C (% DM) + F (% DM))

Where P is the protein content (%); Lis the lipid content (%); *C*is the ash content (%);Fis thedietary fiber content (%) and Gis the carbohydrate content (%).

Extraction with methanol for the determination of antioxidant compounds

The samples of cassava leaves are crushed, the crushed are weighed and a volume of a menthol solution corresponding to the different masses of crushed were taken then poured into flasks of known mass and labeled, the extraction is carried out under a magnetic stirrer hot for 4h, the extracts are obtained after evaporation of methanol in the rotavapor and the mass of the flask containing the extracts are weighed to determine the yield.

Yield of extracts(%) = ((m_1-m_2) x 100)/me

Where $m_1$is theempty flask mass (g) + grinded material mass (g):$m_2$is the flask mass after extraction(g) and*me*is thesample mass (g)

Determination of polyphenol content

For the determination of polyphenols 20 µl of extract are added to 100µl of Folin's reagent solution in 96-well plates (0.2N). The plate containing the solutions is shaken for 30 seconds, incubated in the dark and then 80 µl of Na2CO3 is added. The plate is shaken again for 30 seconds with 15 minutes of incubation at room temperature.The absorbance is read with a plate reader at 765 nm. Gallic acid is the reference used for this test. If the extract absorbs, the blanks of the extract are subtracted from the absorbances read from the extracts.

Determination of flavonoids

The method of flavonoid assay was described by [3] .In a 96-well costar plate ,100µl of extract (3mg/ml)+100µl of AlCl3 (1g/50ml of MeOH) +100µl of MeOH) + 100µl of MeOH were put .

For the control blank, 100µl of methanol is added to 200µl of solvent used to dissolve the extract. The measurement is done after 15 minutes of incubation at room temperature, the absorbance of the extract is measured at 415 nm. The flavonoid content in the samples was analyzed on Excel with a spectrophotometer connected to the computer.

Tannin assays

The method of tannin assay was described by [3] . A volume of 50µl of extract is added to 150µl of 1% vanillin solution in H2SO4 (7M). The mixture is incubated at 250C for 15 minutes and the absorbance is measured at 500nm. The amount of tannins in the samples was determined via a computer, and the results are processed in Excel expressed as mg catechin equivalent/g dry matter (DM) and catechin is the reference.

Determination Of anti-nutritional compounds (hydrocyanic acid)

The hydrocyanic acid content is determined according to the method described by [2]. 10 g of dried and ground sample in a distillation flask and 200 mL of distilled water were added. Distillation of the mixture was carried out for 3 h by trapping the distillate in a 250 mL receiving flask containing 50 mL of 2.5% NaOH. The distillate was subsequently made up to the mark with distilled water. After removing 100 mL of the mixture, 2 mL of 5% KI is added and titrated with 0.02 M AgN03 solution until cloudiness appears. The content of hydrocyanic acids is given by the following the expression:

$$\text{Hydrocyanic acids (mg/l00g)} = \frac{1.08\,Veq \text{ x } 2.5\,x100}{me}$$

Where Vcq is the volume (ml) of AgN03 poured at the equivalenceand me is the mass (g) of the sample.

Analysis of the data

According to the number of repetitions (n=3) the non-parametricWilcoxon test was used to compare two to two means. The threshold of probability for a significant difference is 5% and all the treatments were made with the software R (version).

Results

Fiber content

Table I presents the results of dietary fiber content in cassava leaves. The highest fiber content (43%) is determined in healthy cassava leaves. The fiber content decreases in cassava leavesinfected with mosaic virus according to the Disease Symptom Severity Index (DSI). Cassava leaves with DSI_0, DSI_1, DSI_2, DSI_3, DSI_4 and DSI_5 contained (41%, 38%, 33%, 39%, 26% and 28%) of fiber. This allowed us to deduce that the virus infection leads to a decrease in dietary fiber content in cassava leaves of infected plants.

Table I: Dietary fiber content of cassava leaves samples

Samples	**Mass (g) of Samples**	**Mass (g) of Dried residue m1(mean±SD)**	**Mass (g) of ash m2(mean±SD)**	**Fiber content (%)**
Healthy Leaf (control)	2	0.894±0.03	0.024±0.0045	43
DSI_0	2	0.933±0.12	0.095±0.0105	41
DSI_1	2	0.807±0.3	0.045±0.009	38
DSI_2	2	0.713±0.11	0.035±0.0038	33
DSI_3	2	0.803±0.04	0.010±0.0015	39
DSI_4	2	0.586±0.05	0.010±0.0011	26
DSI_5	2	0.625±0.03	0.060±0.0065	28

Protein content

Figure (3) shows the results of protein content determination in healthy and mosaic virus infected cassava leaves. According to the results healthy cassava leaves contain 3% protein. The protein content of cassava leaves infected with the mosaic virus varies according to the Symptom Severity Index (SSI). Cassava leaves from diseased plants at DSI_0, DSI_1 and DSI_5 contain (3%) protein. The protein content in cassava leaves from diseased plants at DSI_2, DSI_3, DSI_4 is (4%) The increase in protein content from 3 to 4% could be explained by the fact that the virus-plant interaction stimulated the synthesis of additional proteins in the infected plants. Thus, the increase in protein content in cassava leaves infected with mosaic virus is related to the plant's defense mechanism. This justifies that cassava leaves of mosaic virus infected plants contain more protein than cassava leaves of mosaic resistant plants.

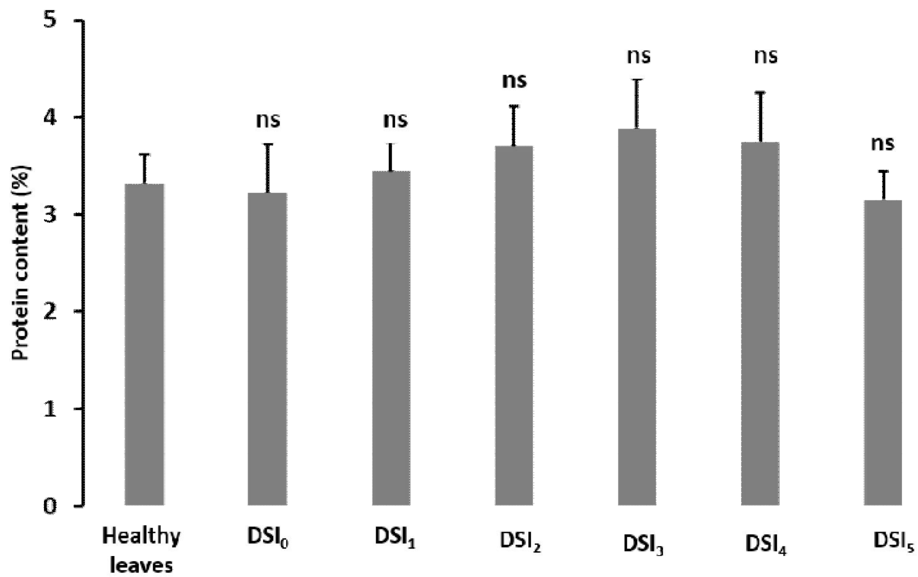

Figure 3.Protein content in leaves (n=3)of mosaic-infected and healthy cassava leaves. No significant difference was found between the values following comparison to healthy leaves(Wilcoxon test, P>0.05); ns = non-significant difference.

Lipid content

Figure 4 shows the results of lipid content in samples of mosaic-infected and healthy cassava leaves. The lipid content is high in the DSI_1 mosaic virus infected cassava leaves (7%). Cassava leaves of mosaic resistant plants contain (5%) lipid with a significant difference $P<0.05$. The lipid content in leaves infected withDSI_0,DSI_2, $DSI_3$$DSI_4$,$DSI_5$,varies between (2 to 4 %). These results show that the lipid content decreases in cassava leaves infected with mosaic virus according to the degree of disease symptom. Thus, the virus infection leads to a disruption of the metabolism of the infected plant,variesbetween (2 to 4 %). These results show that the lipid content decreases in cassava leaves infected with mosaic virus according to the degree of disease symptom. Thus, the virus infection leads to a disruption of the metabolism of the infected plant.

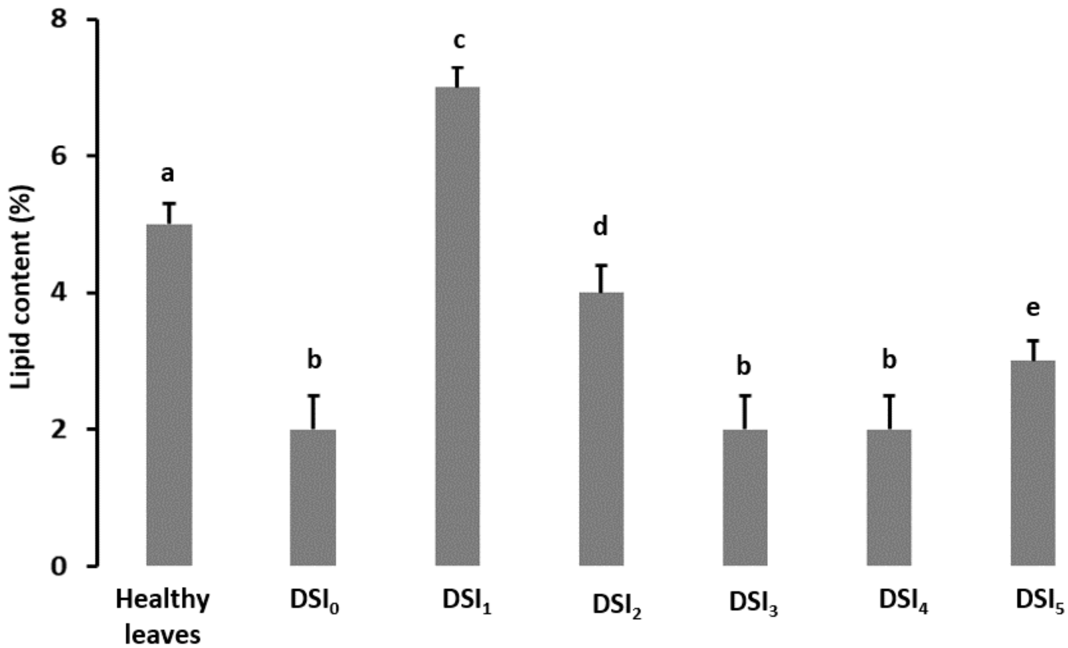

Figure 4. Lipid content in leaves (n=3)of mosaic-infected and healthy cassava leaves. Histograms with different letters are statistically different (Wilcoxon test, P<0.05).

Carbohydrate content

Figure (5) presents the results of the determination of carbohydrate content in infected and healthy cassava leaves. The carbohydrate content is highest in DSI_5 infected cassava leaves (59%) while the lowest carbohydrate content is in healthy cassava leaves (39%). Statistical analysis reveals that there is a significant difference P<0.05, between the carbohydrate content in mosaic virus infected cassava leaves and healthy cassava leaves. It was found that there was an increase in the carbohydrate content in the infected cassava leaves. This led to the understanding that the defense mechanism developed by the infected cassava plant provides energy in the form of carbohydrates. This could explain this increase in sugar content in mosaic-infected leaves compared to healthy cassava leaves.

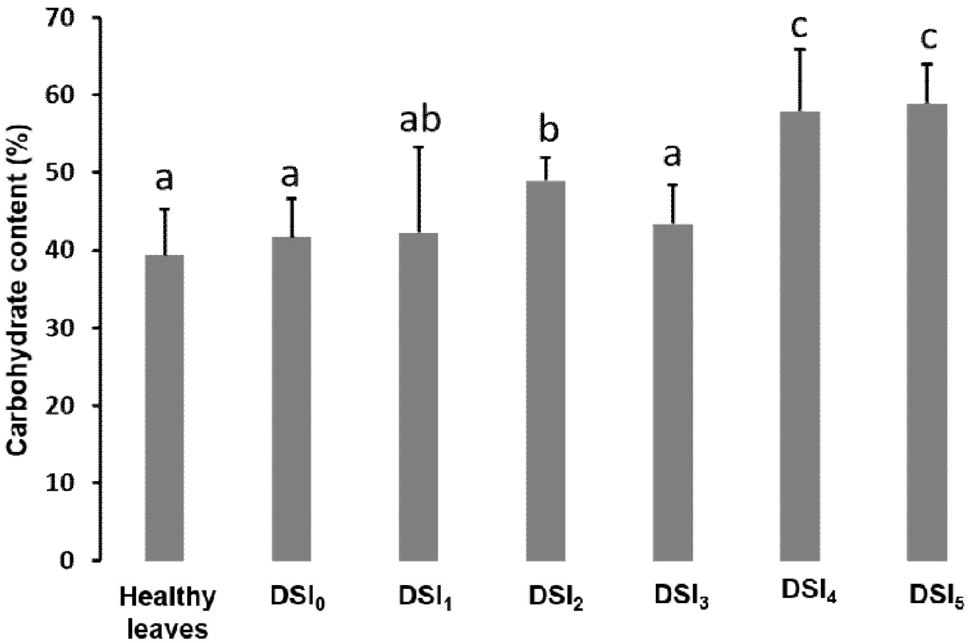

Figure 5. Carbohydrate content in leaves (n=3)of mosaic-infected and healthy cassava leaves. Histograms with different letters are statistically different (Wilcoxon test, $P<0.05$)

Yield of methanol extracts

The table below presents the yield of total extracts of the cassava leaf samples for the different biochemical tests, polyphenols, tannins, flavonoids.

Table II. Yield of the extractionwith methanol in mosaic-infected and healthy leaves samples

Samples	Mass (g)	Volume of methanol (ml)	Balloon mass before extraction	Mass of the Balloon and after extraction	Mass of the extract	Performance (%)
Healthy leaves	.3250	230.00	70.64	77.90	7.26	22.33
DSI_0	22.60	159.93	141.3	147.40	6.10	26.90
DSI_1	2.50	20.00	59.6	60.20	0.6	24.00
DSI_2	4.90	39.20	58.2	57.00	1.25	25.00
DSI_3	13.80	110.04	80.01	85.22	1.21	37.50
DSI_5	7.70	60.16	80.09	8187.	1.78	23.11

Polyphenol content

The results illustrated in (Figure 6) show that, the low polyphenol concentration is observed in the infected cassava leaves at DSI_0, and there was an increase in polyphenol content in the cassava leaves infected with mosaic virus at DSI_1, DSI_2, DSI_3, DSI_4 and the cassava leaves of the disease resistant plants. Statistical analysis showed that there was no significant difference between the polyphenol content in the infected and healthy cassava leaves except for the DSI_0 infected cassava leaves. From these results, it was understood that the polyphenol content is low in cassava leaves of mosaic-infected plants. This could explain that the increase in polyphenol content in cassava leaves infected with mosaic virus is related to the defense mechanism developed by the plant during the different stages of virus infection. Thus, virus infection promoted the increase in polyphenol content in cassava leaves infected with mosaic virus. The infected cassava leaves contain polyphenol molecules with antioxidant properties

Figure 6: Polyphenol content in leaves (n=3)expressed as milligram equivalent Gallic acid per gram (mg eq GA/g). No significant difference was found between the values except for the one of the leaves at DSI_0 which is very significantly different compared to healthy leaves (Wilcoxon test, $P<0.05$); ns = non-significant difference.

Flavonoid content

Figure 7 shows the results of flavonoid content in cassava leaves infected with mosaic virus and cassava leaves not infected with mosaic virus. From these results, it appears that there was an increase in flavonoid content in healthy (resistant) cassava leaves and infected cassava leaves with a Severity Index (DSI_0).

While a decrease in flavonoid content was revealed in infected cassava leaves with Severity Indices (DSI_1, DSI_2, DSI_3, DSI_4, and DSI_5). This decrease in flavonoid content may be related to discoloration or yellowing of cassava leaves. There was no discoloration of healthy cassava leaves and leaves infected with DSI_0. This means that the low flavonoid content would have indicated that these molecules play an important role in the defense mechanism of cassava plants. The results of the statistical analyses show a significant difference between healthy and mosaic-infected cassava leaves. Flavonoids are antioxidant compounds that are useful for health purposes.

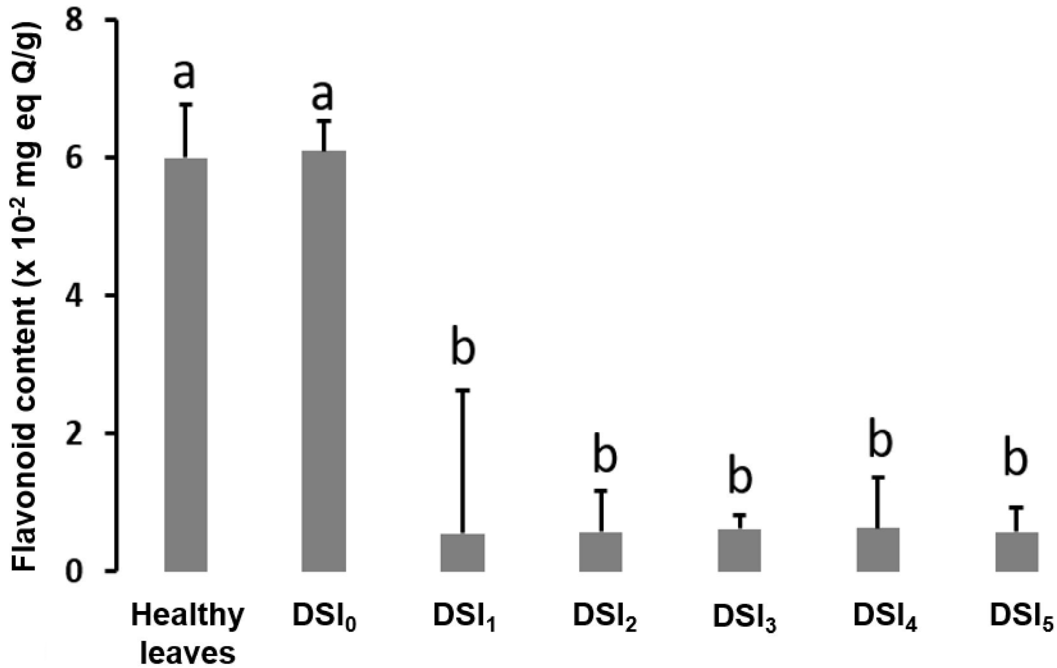

Figure 7: Flavonoid content in leaves (n=3)expressed as milligram equivalent Quiercetin per gram (mg eq Q/g). Histograms with different letters are statistically different (Wilcoxon test, $P<0.05$).

Tannin content

The results of tannin content in healthy (resistant) and mosaic virus infected cassava leaves shown in (Figure 8) are statistically different. It can be seen that the tannin content is very low in cassava leaves infected with mosaic virus with a Severity Index (DSI_0). But also we notice that the tannin content is low in healthy (resistant) and infected cassava leaves with a Severity Index (DSI_4). There was an increase in tannin content in infected cassava leaves with Severity Indexes (DSI1, DSI_2, DSI_3, DSI_5). These results showed that, the viral infection would have promoted the synthesis of tannin molecules in cassava leaves (DSI_1, DSI_2, DSI_3,DS_{I5}) . This could show that the tannin molecule was developed to participate in the defense mechanism of cassava plants during virus infections. The tannin molecules synthesized in cassava leaves infected with mosaic virus are useful for food and therapeutic purposes.

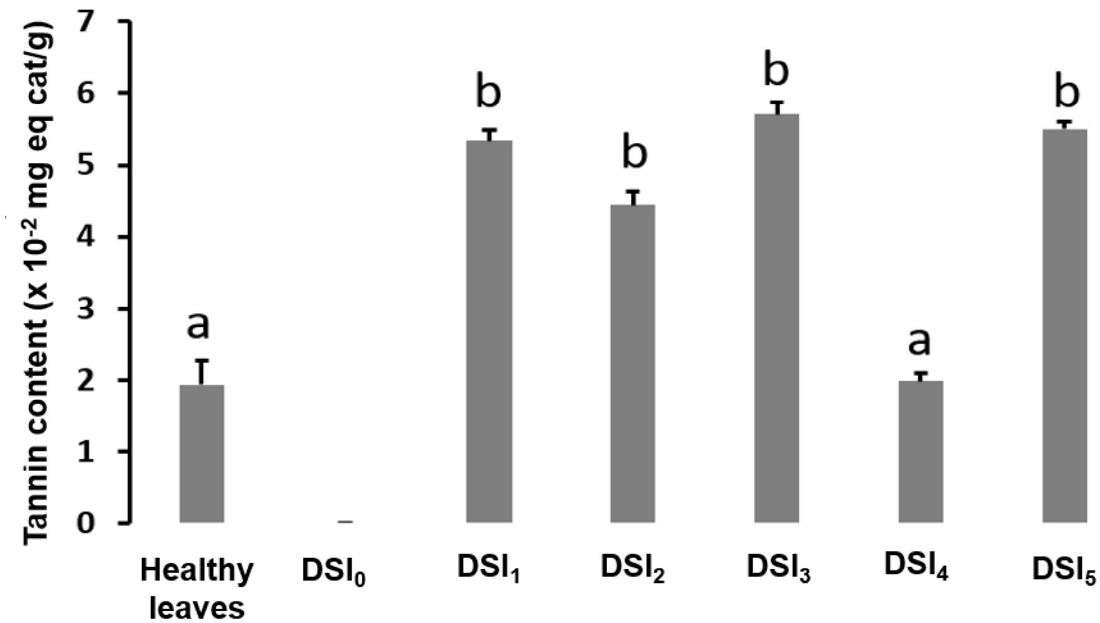

Figure 8: Tannin content in leaves (n=3)expressed as milligram equivalent catechin per gram (mg eq Q/g). Histograms with different letters are statistically different (Wilcoxon test, $P<0.05$

Cyanide content

Table III shows the cyanide content in cassava leaves infected with mosaic virus and healthy cassava leaves. Healthy cassava leaves contain 20±92mg/ 100g of cyanide. Cassava leaves infected with mosaic virus with Severity Index (DSI_0) contain 18±41mg/100g . Cassava leaves infected with mosaic virus with Severity Indexes, (DSI_1,DSI_2 ,DSI_3, DSI_4) contain 14±44mg /100g of cyanide . Cassava leaves with mosaic symptoms with Severity Index (DSI_5) contain 13±44mg . These results show that the cyanide content decreases with the disease severity index. This led to the understanding that cassava leaves of mosaic virus infected plants contain less cyanide than cassava leaves of healthy plants with a significant difference. The virus infection would have favored the decrease of cyanide content in cassava leaves.

Table III. Cyanide contentof cassava leaves samples

Samples	**Control**	**DSI_0**	**DSI_1**	**DSI_2**	**DSI_3**	**DSI_4**	**DSI_5**
Cyanide content (mg/100g)	20 ±92	18 ±14	14±14	14±14	14±41	14±41	13±44

Discussion

Cassava leaves are a food of higher nutritional quality consumed in many African communities. This research evaluated the content of organic compounds synthesized in cassava leaves during the primary and secondary metabolism process of the plant. The results of the biochemical analyses showed that the fiber content is higher in the leaves of mosaic-resistant plants. In the leaves of infected plants there was a variation in fiber content according to the degree of disease severity. This allowed to understand that the viral infection stimulated a dysfunction during the synthesis process of organic molecules in cassava plants infected by mosaic.

The results of this studyshowed that cassava leaves of mosaic-infected plants have a high protein content compared to leaves of mosaic-resistant plants. They confirm the results of studies conducted by [19]. This stated that the viral infection promoted protein biosynthesis and the synthesized proteins participate in the defense process developed by the infected plant. According to [5]. Viral infections induce changes in the amino acid content that seem to have an important role in the establishment of the plant's defense mechanisms. These results correlate with those of the finding of[17]. Changes in amino acid concentrations were demonstrated during Tomato yellow leaf curl virus (TYLCV) infection of resistant and susceptible tomato varieties. Indeed, at an early time after inoculation the resistant varieties have a higher amino acid content than the susceptible varieties. During infection, the result is reversed with an accumulation of metabolites that becomes maximal in susceptible varieties. This confirms that cassava plants infected with mosaic virus contain more protein content than mosaic-resistant cassava plants. Protein synthesis plays a role in the defense system of mosaic-infected cassava plants.

Other results showed that there was a decrease in lipid content in cassava leaves of mosaic-infected plants compared to leaves of mosaic-resistant plants. This explains that the virus infection has an effect on the physiological functioning of the plant and impacts the production of lipids. According to [4].during infection, viruses interact with lipid and fatty acid metabolism with the aim of facilitating its entry into the cells.

The results of the biochemical analyses carried out also showed that the carbohydrate content is higher in leaves infected with cassava mosaic virus, they confirm the hypotheses stated by [15], that the improvement of taste would be related in part by a high sugar content in the infected leaves. These results are consistent with the work of[4], which demonstrates that a significant phenomenon is observed at the tissue level of plants infected within the case of a viral infection, respiration is stimulated in order to meet the energy requirements for the development of defense mechanisms and/or viral multiplication [9] . During a viral infection, respiration is stimulated in order to meet the energy requirements necessary for the implementation of defense mechanisms and/or viral multiplication [9] . Thus, sugars are synthesized to produce energy for the defense mechanism developed by the infected plants.

From the above, the primary metabolism of mosaic-susceptible cassava varieties is involved in the production of energy to support the defense mechanisms and may also play a role in the process of virus multiplication. This justifies the increase in protein and carbohydrate content and the improvement of the organoleptic quality of cassava leaves from plants infected by the mosaic virus.

The research conducted studied the polyphenol content in cassava leaves of resistant and mosaic-infected plants. The results showed that polyphenols are highly concentrated in the resistant plants but also in the mosaic-infected plants. The polyphenol content is relatively low in DSI_0 infected cassava leaves. It is also noted that the polyphenol content is high in cassava leaves infected with DSI_1, DSI_2, DSI_3, DSI_4, DSI_5. This explains the polyphenols are synthesized to participate certainly in the resistance of the plant in the presence of the mosaic virus. These assertions have been confirmed by the findings of[13] , the polyphenols play a role of protection of the plants against the microbial invasions, and present other mechanisms of action of fight against the fungi, bacteria and virus. The antifungal and antiviral properties have many applications in human medicine. It is understandable that cassava leaves infected by the mosaic virus is a good source of polyphenols which are molecules with antioxidant properties. This allows to understand why people use cassava leaves infected by the mosaic virus to treat chickenpox which is a viral disease. But also many works demonstrate that polyphenols have anti-inflammatory properties, and that they are able to modulate the functioning of the immune system [14]. As well as antioxidant properties that participate in the prevention of various pathologies involving oxidative stress and cellular aging [13]

According to the results, the flavonoid content decreases in cassava leaves of plants infected by the mosaic virus. The flavonoid content is relatively high in cassava leaves of mosaic-resistant plants but also in samples of DSI_0 asymptomatic cassava leaves. It should be noted that the presence of flavonoids in the plant may be correlated with the chlorophyll content. According to[19] virus infection leads to chlorophyll depletion and depigmentation of the plant leaves. Indeed, flavonoids also play a role in the coloration of some plant organs, so depigmentation could have an effect on flavonoid content. These results are confirmed by the work[10] which shows that, at the cellular level, flavonoids are synthesized in chloroplasts and then migrate and dissolve in vacuoles, the distribution of these compounds shows very localized accumulations, generally related to a physiological function and the interaction of the plant with the biotic and abiotic conditions of their environments. This allowed to understand that flavonoids play an important role in the defense mechanism of the plant and that in the absence of flavonoids the plant develops a sensitivity to the mosaic virus. The results also showed that cassava leaves infected with mosaic virus contain more tannins compared to uninfected cassava leaves. This suggests that the high tannin content is stimulated by the presence of the mosaic virus. The presence of tannins in the plant would play a determining role in the resistance of the plant. So according to [10], tannins promote tissue regeneration in case of superficial wounds or burns. They have a vasoconstrictor effect on small superficial vessels. Whatever the route of administration, the antiseptic, antibacterial and antifungal effect is interesting, especially for infectious diarrhea and dermatosis.Through these results. It has been demonstrated that the infection of cassava plants by the mosaic virus has caused a dysfunction in the defense mechanism, allowing the synthesis of organic molecules useful for food and therapeutic purposes.

Conclusion

In the Central African Republic, cassava leaves are a foodstuff regularly consumed by the population and are sold at low cost on urban and rural markets. Cassava leaves infected with the mosaic virus are among the most popular vegetables, but their nutritional characteristics are not yet well known. The results of this study showed that the infected cassava leaves have a high level of protein, carbohydrates and lipids. The study showed that cassava leaves infected with the mosaic virus are a source of antioxidant compounds such as polyphenols, flavonoids, and tannins. Cassava leaves from mosaic virus infected plants are nutritionally and therapeutically useful. These studies have provided knowledge to contribute to research on the control of cassava mosaic virus in Central Africa.

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