

## COVID-Med syrup for children from the association of significant parts of anti-COVID-19 medicinal plants from the Centre, Cameroon

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**Abstract.** Lamy GML, Nnanga LS, Mahama, Ossongo AF, Elomo LB, Tagne RS, Mbo JA, Likeng JLN, Nga EN, Harmsen K. 2023. COVID-Med syrup for children from the association of significant parts of anti-COVID-19 medicinal plants from the Centre, Cameroon. *Asian J Nat Prod Biochem* 21: 58-66. In Africa, Improved Traditional Medication (ITM) has been promoted since 1970 and classified into four categories. The import-substitution policy under the "Made in Cameroon" label encourages local production. Globally, there is an urgent need for anti-COVID-19 drugs, especially for children. The mechanisms of action of SARS-CoV-2 can be attenuated by combination therapy of the parts of anti-COVID-19 medicinal plants. A plant has several parts whose therapeutic properties generally differ. From 2020 to 2022, the most cited anti-COVID-19 plants in the literature were *Allium sativum* L., *Citrus × limon* (L.) Burm.fil., *Cymbopogon citratus* (DC.) Stapf, and *Zingiber officinale* Roscoe. Unfortunately, a gap exists in the names of the significant parts of these plants. For example, were the barks, leaves, roots, or flowers used? In addition, the significant association of said plants and the majority of traditional preparation methods are not specified. The objective was to determine the significant parts of 4 anti-COVID plants, their significant association, and the majority traditional method of preparation allowing the pre-formulation of an infant anti-COVID ITM syrup. An ethnomedicinal survey, ANOVA, and the pre-formulation protocol of a medicated syrup were used. Altogether, 180 informants from several ethnic groups participated. The bulb and rhizome parts for *A. sativum* and *Z. officinale* showed a significant difference ( $P < 0.05$ ) between plants. The leaves and fruits of *C. citratus* and *C. limon* showed a highly significant difference ( $P < 0.000$ ) between plants. The association of four significant plants and infusion, the majority traditional mode of preparation, allowed the pre-formulation of the infant syrup named COVID-Med, an ITM category 2. The bulbs, rhizomes, leaves, and fruits were significant parts of *A. sativum*, *Z. officinale*, *C. citratus*, and *C. limon*.

**Keywords:** Coronavirus, ethnomedicine survey, improved traditional medication, medicated syrup protocol, traditional extraction method

### INTRODUCTION

The import-substitution policy is one of the three fundamental orientations of Cameroon's national development for strategy 2020-2030 (SND30) (MINEPAT 2020). In import-substitution, it is a question of producing locally and promoting the use of local products through the label "Made in Cameroon." In the 1970s and at the very beginning of the 1980s, most African states implemented policies to promote traditional therapies under the impetus of various international organizations (like the World Health Organization, African Organization, African and Malagasy Council for Higher Education). These policies are based on a common premise: the biological effectiveness of traditional treatments; their development as Improved Traditional Medication (ITM). Official

recommendations encourage traditional health practitioners to change some practices to achieve rigorous botanical identification, precise dosage, better hygiene, and the development of galenic forms and packaging (Simon and Egrot 2012).

For a long time, there has been a discussion that children cannot get COVID-19. It is now established that children are indeed affected (Zimmermann and Curtis 2020). COVID-19 is returning worldwide following its resurgence in China (Cowling 2023; Dyer 2023; Huizhong and Aniruddha 2023). The clinical manifestations of COVID-19 are multifactorial with comorbidities (Oladele et al. 2020). A combination therapy, such as the association of parts of two or more plants with specific therapeutic actions on SARS-CoV-2, is recommended to combat the mediators of the disease. Recently, in India, it has been

demonstrated that for greater effectiveness, anti-COVID-19 plants must be put together and then transformed into biomedicines (Pattanayak 2021). However, there are almost no proposals yet to transform the combinations of the parts of several anti-COVID-19 plants into dosage forms such as ITM syrups for children that are easily accessible to them. Between 2020 and 2022, among the most cited anti-COVID-19 plants in the literature were *Allium sativum* L. (Oladele et al. 2020; Alhazmi et al. 2021; Pattanayak 2021; Ugwah-Oguejiofor and Adebisi 2021; Odebunmi et al. 2022), *Citrus ×limon* (L.) Burm.fil. (Pattanayak 2021; Odebunmi et al. 2022), *Cymbopogon citratus* (DC.) Stapf. (Oladele et al. 2020; Ugwah-Oguejiofor and Adebisi 2021; Odebunmi et al. 2022) and *Zingiber officinale* Roscoe (Oladele et al. 2020; Alhazmi et al. 2021; Pattanayak 2021; Ugwah-Oguejiofor and Adebisi 2021; Odebunmi et al. 2022).

Unfortunately, information is lacking on the names of the exact parts (roots, bark, leaves, flowers, and the other parts) of these plants used against the symptoms of this disease. Therefore, to understand these shortcomings, hypotheses can be made. The first hypothesis concerns the objectives targeted by the authors. Perhaps the names of the parts of these plants were not part of the author's intentions. In this case, these authors keep readers in the dark because the latter do not know which specific part(s) of the plants mentioned should be used against the disease.

Consequently, a reader can use a whole plant through ignorance, thus neutralizing the desired therapeutic effect. However, only part of the said plant was needed. The second hypothesis relates to the ignorance of the authors. Perhaps the authors were unaware that not all medicinal plant parts have the same curative, palliative, and preventive therapeutic properties. In this case, there is a

risk of adverse effects linked to the choice of part of the plants mentioned instead of another part of the same plants. As a result, a reader may randomly select a part of a plant that is acutely toxic, and the worst ensues.

The objective of this study was to determine the parts significant of the 4 anti-COVID-19 plants *A. sativum*, *C. limon*, *C. citratus*, and *Z. officinale*, the significant association of these plants and the traditional method of preparation allowing the pre-formulation of an infant anti-COVID-19 ITM syrup in Centre Province, Cameroon.

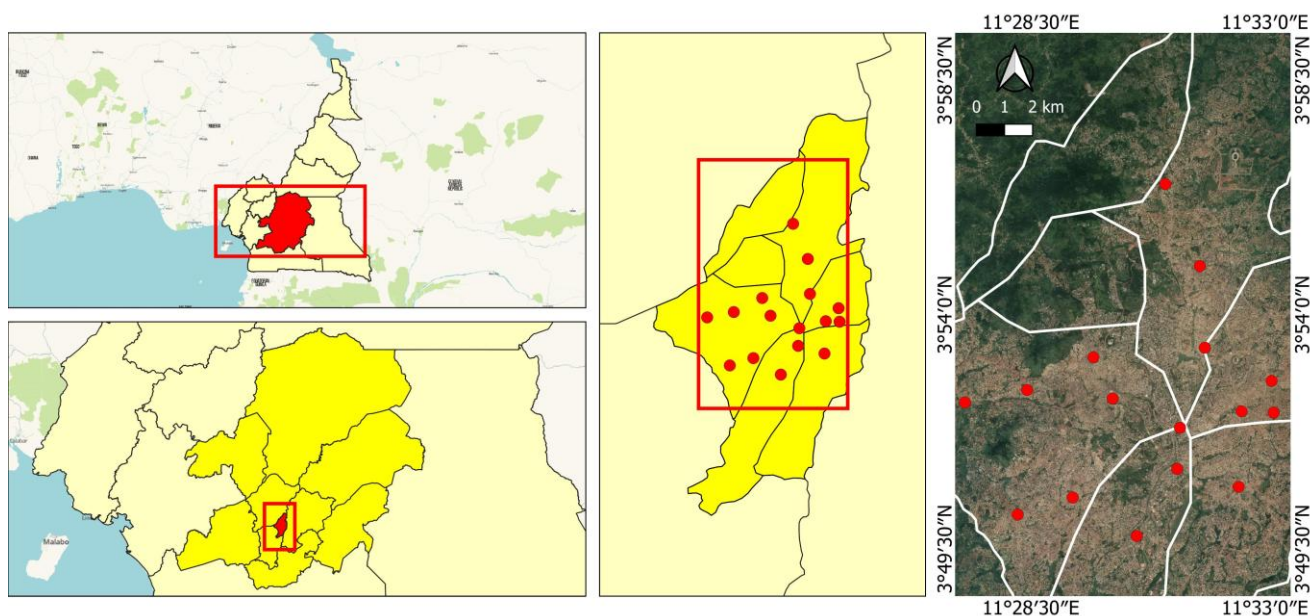
## MATERIALS AND METHODS

### Study area

The study took place in the Mfoundi District, Centre Province, Cameroon (Figure 1), precisely in four sub-districts (Yaoundé 1, Yaoundé 2, Yaoundé 3, and Yaoundé 4) (Oyono 2015). The climate is punctuated by two dry seasons alternating with two wet seasons, with rainfall of 1600 mm on average per year. The temperature fluctuates between 18°C and 28°C in the wet seasons, 16°C and 31°C in the dry seasons. The vegetation of the Mfoundi district is of the intertropical type with a predominance of the southern humid forest. The soils are mostly red lateritic.

### Identification of botanical samples

Botanical samples of plant parts (leaves, rhizomes, pods, fruits, flowers) collected in the study area were identified at the Cameroon National Herbarium (CNH), Yaoundé District. The collected plant specimens were compared with those from the related collections.



**Figure 1.** Location of the study area in the Mfoundi District, Centre Province, Cameroon

### Ethnomedicine

Data was collected based on the availability of informants. Sampling was carried out on a non-probability (random) basis. All informants voluntarily gave their informed consent either by name or anonymously. Three markets were visited per Sub-district. Fifteen informants were interviewed per market, that is, forty-five per borough. The informants had to name the most used part for each of the four plants *A. sativum*, *C. limon*, *C. citratus*, and *Z. officinale*. Following the recommendations of the Nagoya Protocol on access and benefit-sharing from local knowledge, informants who agreed to participate by name were cited as co-authors (Maxime et al. 2020).

### Syrup preparation

It is a question of preparing a medicated syrup for ten bottles of 125 mL each, i.e., totaling 1,250 mL. According to the European Pharmacopoeia, the medicated syrup is prepared in two stages: preparing the simple syrup and incorporating the medicinal and aromatic active ingredients (Dénou et al. 2021). Moreover, for a final 100% medicated syrup, the value of the extract is 4.32%, that of the simple syrup 95.25%, that of the preservative 0.4%, and that of the aroma 0.03%.

### Traditional extraction method by infusion

The goal is to obtain an infused extract obtained from a concentrated infusion of 119.5 g of *C. limon* fruit juice; 28.3 g of bulbs of *A. sativum*; 80 g of fresh *Z. officinale* rhizomes then 86.4 g of *C. citratus* leaves for 2 L of water.

### Operating mode

Measure 2 L of distilled water using the Beaker. Then, this water is introduced into a stainless steel container. Then, carefully wash some fresh fruits of *C. limon*, cut them in half, squeeze the juice into the Beaker, and weigh 119.5 g. The next step is to clean, wash and weigh 28.3 g of fresh bulbs of *A. sativum* and grind them in a porcelain mortar. The next step is cleaning, washing, and weighing 80 g of fresh *Z. officinale* rhizomes, then grinding them in the mortar. Subsequently, wash and weigh 86.4 g of fresh leaves of *C. citratus*, then keep them. The next step is to boil the 2 L of distilled water in the stainless steel container on the hot plate at 90 to 100°C. Then, stop the plate once the steam has escaped from the stainless steel container, and remove the container from the heating plate. By systematically closing the lid after adding each component, Lift the lid of the container and gradually introduce the *C. limon* juice, the crushed *Z. officinale* rhizomes, and the already crushed *A. sativum* bulbs. Finally, introduce the previously washed *C. citratus* leaves and close the container hermetically. Leave the active substances of the plants in contact with the hot solvent (distilled water) to be released under heat for 10 to 20 minutes. It should be left to cool for about 30 minutes. Filter or sieve the extract using the funnel and cotton, then keep the extract cool in tinted containers or covered with aluminum foil to protect the extract from light. The infused product is put in a tray and brought to evaporation in an oven calibrated at 60°C. After 24 hours, the vegetable matter devoid of water is removed

from the oven and kept away from light. Following the European Pharmacopoeia, only 4.32% of all the final infused was taken for the rest, the infused, that is to say, the extract composed of the active substances (researched active principles) of all the plants used without water.

### Preparation of simple syrup according to the European Pharmacopoeia

The ingredients are taken for an amount of 100%. Remember that  $100\% = 100 \div 100 = 1 = 1 \text{ L (liquid) or } 1 \text{ g (powder, solid) = } 1000 \text{ mL or } 1000 \text{ mg}$ . Hence the following proportions: sucrose (powder):  $65\% = 65 / 100 = 0.650 \text{ g} = 650 \text{ mg}$ ; distilled water (liquid):  $35\% = 35 / 100 = 0.35 \text{ L} = 350 \text{ mL}$ . Thus, for a quantity of 3.5 L or 3,500 mL, the necessary ingredients will be: sucrose (powder, solid):  $650 \times 3,500 = 2,275,000 \text{ mL} = 2,275 \text{ L}$ ; distilled water (liquid):  $350 \times 3,500 = 1,225,000 \text{ mL} = 1,225 \text{ L}$

### Operating mode

Preparing 3,500 g of simple syrup was discussed by heating sufficient water. The sucrose was dissolved at 80-85°C and then filtered immediately while hot with a previously heated filter. Then, the whole was homogenized and completed at 3,500 g (Dénou et al. 2021).

### Preparation of the syrup composed of several plants according to the European Pharmacopoeia

The proportion of ingredients for 100% =  $100 / 100 = 1 \text{ L or } 1 \text{ g}$ . The following proportions are adopted: extract (containing the active principle):  $4.32\% = 4.32/100 = 0.0432 \text{ g}$ ; simple syrup:  $95.25\% = 95.25 / 100 = 0.9525 \text{ L}$ ; preservative (sodium benzoate):  $0.4\% = 0.4 / 100 = 0.004 \text{ g (powder)}$  and flavorings (vanilla + mint):  $0.03\% = 0.03 / 100 = 0.0003 \text{ g}$  hence vanilla (0.02%) and mint (0.01%).

### Preparation of the final syrup composed of several medicinal plants

Since we have ten bottles of 125 mL each, it will be necessary to prepare  $125 \times 10 = 1250 \text{ mL} = 1,250 \text{ L}$  of syrup composed of several medicinal plants, hence the following proportions: extract:  $1250 \times 4.32\% = 54 \text{ mg} = 0,054 \text{ g}$ ; simple syrup:  $1250 \times 95.25\% = 1190,625 \text{ mL} = 1,190.625 \text{ L}$ ; preservative (sodium benzoate):  $1250 \times 0.4\% = 5 \text{ mg} = 0,005 \text{ g}$  and flavorings (vanilla (0.02 g) + mint (0.01 g)):  $1250 \times 0.0003 = 0.375 \text{ mg} = 0.000375 \text{ g}$

### Operating mode

It is necessary to weigh 1190.6 L of simple syrup and then introduce it into the blender. Then, weigh 54 g of extract containing the desired active ingredients then add to the simple syrup. The next step is to mix the extract and the simple syrup. Then, weigh 5 g of preservative (Sodium Benzoate). Next, weigh the aromas, particularly 0.25 g of vanilla and 0.125 g of mint. Then, stir everything until complete dissolution (disappearance of the particles).

### Packaging and labeling

It is packaged in tinted bottles with a capacity of 125 mL. The common is to use the white label for readability and a pleasant presentation.

### Data processing and analysis

The data was processed using Word and Excel 2013 software. Then, an Analysis of Variance (ANOVA) to compare the different data was performed using the STATGRAPHICS Plus 5.0 software.

## RESULTS AND DISCUSSION

### Identification of informants

Therefore, 180 informants participated in the study, i.e., 80 women and 100 men (Table 1). Men were in the majority over women.

### Ethnomedicine

Table 2 presents all the anti-COVID-19 medicinal plants cited in the literature. According to the informants, Each plant has a significantly more used part. For *A. sativum*, the bulbs vary from  $0.41 \pm 0.19$  to  $1.08 \pm 0.19$ . This variation is significant ( $P < 0.05$  since  $0.03 < 0.05$ ) between said plants; this result reflects that the bulbs represent the most used part of the plant, according to the informants. Concerning *C. limon*, the variation of the fruit means ranges from  $0.5 \pm 0.17$  to  $2.08 \pm 0.17$ . This variation is highly significant ( $P < 0.05$  because  $0.000 < 0.05$ ) between all the plants; this result reflects that the fruits are the most used part of the plant, according to the informants. For *C. citratus*, mean leaf responses ranged from  $0.75 \pm 0.16$  to  $2.08 \pm 0.16$ . According to the informants, there is a highly significant difference ( $P < 0.05$  because  $0.000 < 0.05$ ) between all these medicinal plants; this result reflects that

the leaves are the most used part of the plant. Regarding *Z. officinale*, a variation of  $0.5 \pm 0.22$  to  $1.33 \pm 0.22$  is observed at the level of the rhizomes. According to the informants, this variation is significant ( $P < 0.05$  because  $0.02 < 0.05$ ) between said plants; this result reflects that the rhizomes represent the most used part of the plant.

The analysis of Table 3 shows that for all the associations of medicinal plants, a variation of garlic (*A. sativum*) ranges from 0.5 (association of 2 plants) to 1.08 (association of 4 plants) with an average of  $0.49 \pm 0.19$ . This variation is significant ( $P < 0.05$  because  $0.04 < 0.05$ ) between said associations. This result reflects that garlic is used in combinations of 2 and 3 medicinal plants according to the same number of informants, but this number differs from the higher number who think that garlic is used in the combination of 4 plants. Regarding lemon (*C. limon*), the average is  $0.63 \pm 0.17$ . The maximum is found in the association of 4 medicinal plants ( $0.9 \pm 0.17$ ), and the minimum in 2 medicinal plants ( $0.5 \pm 0.17$ ). There is no significant difference ( $P > 0.05$  because  $0.14 > 0.05$ ) between the different combinations of medicinal plants in using lemon.

**Table 1.** Names of sub-district, gender, and total informants

| Sub-districts | Women | Men | Total |
|---------------|-------|-----|-------|
| Yaoundé 1     | 21    | 24  | 45    |
| Yaoundé 2     | 19    | 26  | 45    |
| Yaoundé 3     | 18    | 27  | 45    |
| Yaoundé 4     | 22    | 23  | 45    |
| Total         | 80    | 100 | 180   |

**Table 2.** Anti-COVID-19 medicinal plants from the literature, averages, p-values, and most used parts cited by informants

| Anti-COVID-19 Medicinal Plants from the Literature | Most Used Parts Cited by informants |                  |                  |                  |
|--|-------------------------------------|------------------|------------------|------------------|
|  | Bulbs                               | Fruits           | Leaves           | Rhizomes         |
| <i>Allium sativum</i> L.                           | $1.08 \pm 0.19c$                    | $0.5 \pm 0.17a$  | $0.75 \pm 0.16a$ | $0.5 \pm 0.22a$  |
| <i>Citrus ×limon</i> (L.) Burm.fil.                | $0.5 \pm 0.19ab$                    | $2.08 \pm 0.17b$ | $0.83 \pm 0.16a$ | $0.5 \pm 0.22a$  |
| <i>Cymbopogon citratus</i> (DC.) Stapf             | $1.0 \pm 0.19bc$                    | $0.91 \pm 0.17a$ | $2.08 \pm 0.16b$ | $1.0 \pm 0.22ab$ |
| <i>Zingiber officinale</i> Roscoe                  | $0.41 \pm 0.19a$                    | $0.5 \pm 0.17a$  | $0.91 \pm 0.16a$ | $1.33 \pm 0.22b$ |
| Means  | $0.75 \pm 0.18$                     | $0.99 \pm 0.17$  | $1.33 \pm 0.16$  | $0.83 \pm 0.22$  |
| P-values   | 0.03                                | 0.000            | 0.000            | 0.02             |

Note: At the 5% significance level (0.05), the means followed by the same letter on the vertical are statically identical

**Table 3.** Association of medicinal plants, averages, p-values, and medicinal plants most cited by informants

| Association of Medicinal Plants | Informants Most Cite Medicinal Plants |                 |                  |                 |
|---------------------------------|---------------------------------------|-----------------|------------------|-----------------|
|                                 | Garlic                                | Lemon           | Lemongrass       | Ginger          |
| Association of 2 plants         | $0.5 \pm 0.19a$                       | $0.5 \pm 0.17a$ | $0.83 \pm 0.16a$ | $0.5 \pm 0.19a$ |
| Association of 3 plants         | $0.41 \pm 0.19a$                      | $0.5 \pm 0.17a$ | $0.75 \pm 0.16a$ | $0.5 \pm 0.19a$ |
| Association of 4 plants         | $1.08 \pm 0.19b$                      | $0.9 \pm 0.17a$ | $2.08 \pm 0.16b$ | $1.0 \pm 0.19a$ |
| Means                           | $0.49 \pm 0.19$                       | $0.63 \pm 0.17$ | $1.22 \pm 0.16$  | $0.67 \pm 0.19$ |
| P-values                        | 0.04                                  | 0.14            | 0.00             | 0.11            |

Note: At the 5% significance level (0.05), the means followed by the same letter on the vertical are statically identical

This result reflects that lemon is used in all associations of medicinal plants according to the same number of informants. Concerning lemongrass (*C. citratus*), the variation between the associations of medicinal plants ranges from  $0.83 \pm 0.16$  to  $2.08 \pm 0.16$ . A highly significant difference ( $P < 0.05$  because  $0.000 < 0.05$ ) exists between all these plant associations. This result reflects that lemongrass is used in combinations of 2 and 3 medicinal plants according to the same number of informants. However, this number differs from the high number that thinks lemongrass is used in the four-plant combination. Regarding ginger (*Z. officinale*), a variation of  $0.5 \pm 0.19$  to  $1.0 \pm 0.19$  is observed. There is no significant difference ( $P > 0.05$  because  $0.11 > 0.05$ ) between the different combinations of medicinal plants. These results reflect that ginger is used in all associations of medicinal plants according to the same number of informants.

All parts of *A. sativum*, *C. limon*, *C. citratus*, and *Z. officinale* plants contain secondary metabolites (Table 4). Moreover, each of these parts reveals particular therapeutic properties and medicinal uses. These results reflect that the consumption of the combination of these plants is complementary.

Figure 2 shows that infusion is the majority traditional preparation method regardless of the district. This result reflects that concerning the objective of this study, the infusion is the traditional method of preparation for the pre-formulation of the traditional improved anti-infant COVID-19 medicinal syrup.

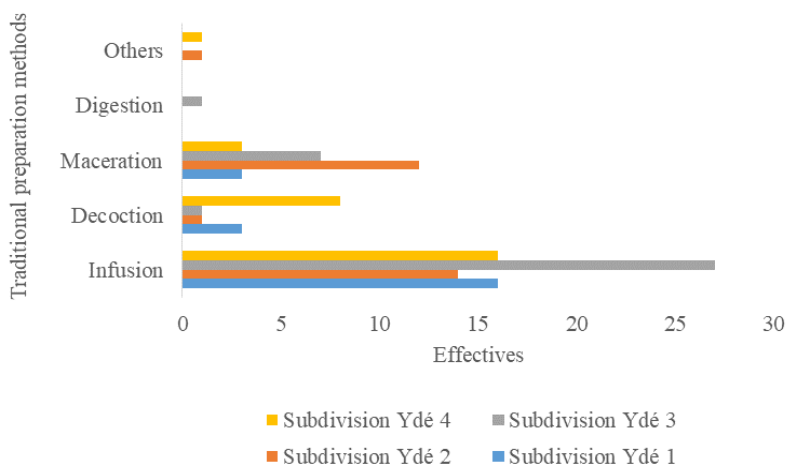


Figure 2. Traditional preparation methods according to numbers

### Results of the preparation of the medicinal compound syrup

Figure 3 shows the labeled vials containing the ITM "COVID-Med" syrup. The presentation of the label reveals: name of the syrup (COVID-Med); extract containing the active ingredient (4.32%); simple syrup (95.25%); preservative (0.4%); aroma (0.03%); place of manufacture (Galenics and Pharmaceutical Legislation Laboratory); date of manufacture (2022.09.16); expiration date (2026.09.15) and lot number (001). These results show that this syrup is derived, among other things, from the combination of the significant parts (bulbs, fruits, leaves, and rhizomes) of the anti-COVID-19 medicinal plants cited in the literature (*A. sativum*, *C. limon*, *C. citratus*, and *Z. officinale*).

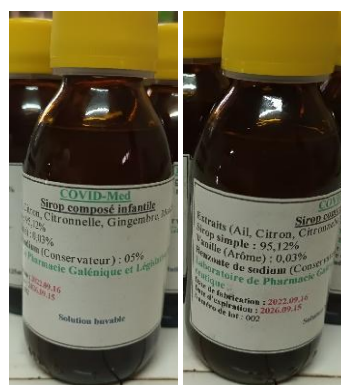


Figure 3. Illustration of labeled bottles containing the syrup named "COVID-Med" Picture. LAMY, October 2022

**Table 4.** Anti-COVID-19 medicinal plants cited in the literature, nomenclature, and characteristics of these plants

| Plant most used in association | Nomenclature   |   |   | Herbarium vouchers numbers | Plants characteristics   |   |  |
|--------------------------------|--|---|---|----------------------------|--|---|--|
|                                | Scientific name/<br>family                           | Common names<br>(French)                        | Local names   |                            | Secondary metabolites  | Therapeutic properties  | Medicinal uses                                     |
| Plant 1                        | <i>Allium sativum</i> (L.)<br>Amaryllidaceae         | <i>Ail</i>                                      | <i>Anyon (Bulu)</i>   | 44810/NHC                  | Pods:<br>1. Carbohydrates<br>2. Proteins<br>3. Fibers<br>4. Prostaglandins (phenol acid, phytosteroids, polyphenols, flavonoids (apigenin, myricetin), etc.)<br>5. Vitamines (B1, B2, C, A, etc.)<br>6. Mineral (potassium, sulfur, phosphorus, calcium, magnesium, sodium, chlorine, etc.)<br>7. Trace elements (Iron, Zinc, Manganese, Boron, Copper, Nickel, Molybdenum, Iodine, Selenium)<br>8. Essential oil (diallyl disulfides, allicin (antibiotic), alliin, alliinase, inulin)<br>(Naganawa et al. 1996; Hussain et al. 2021) | Antiviral (influenza B virus)<br>Hypo-allergenic<br>Digestion<br>Anticoagulant<br>Hypolipidemic<br>Antihypertensive<br>Chelator<br>Antioxidant<br>(Fleischauer and Arab 2001; Ammarellou et al. 2022) | Flu, cold, etc.                                    |
| Plant 2                        | <i>Citrus ×limon</i> (L.)<br>Burm.fil. / Rutaceae    | <i>Citron</i>                                   | <i>Ngoumbang (Bulu)</i><br><i>Ngnofiang (Ngoumba)</i><br><i>Lemoune (Fulfulde)</i>                              | 0565/SRF/CAM               | Fruit:<br>1. Trace elements: calcium; iron; magnesium; phosphorus; potassium; copper; sodium; zinc<br>2. Vitamines: C, B1, B2, B5, B6, A, E, furanocoumarins (psoralen, bergapten)<br>3. Fatty acids: saturated; monounsaturated; polyunsaturates<br>(Nicolosi et al. 2000; Ramón-Laca 2003; Ollitrault et al. 2020)   | Antioxidant<br>Antiinflammatory<br>Diuretic Antiseptic<br>Healing (Carvalho et al. 2005; Klein 2014)  | Flu, Cold, etc.                                    |
| Plant 3                        | <i>Cymbopogon citratus</i> (DC.) Stapf / Poaceae     | <i>Citronnelle</i><br><i>Verveine des Indes</i> | <i>Ossang (Bulu)</i><br><i>Maguianga (Ngoumba)</i><br><i>Fiber grass (Pidjin)</i><br><i>Haco tie (Fulfulde)</i> | 48536/SFR/CAM              | Leaves:<br>1. Tannins (catechic tannins and phlobotanin),<br>2. Phenolic acids (derivates of caffeic and p-coumaric acid),<br>3. glycosides<br>4. flavonoids (apigenin and derivatives of luteolin),<br>5. Saponin (Kiani et al. 2022)   | Antimicrobial, hypoglycemic, hypolipidemic, hypotensive, cardioprotective, anti-inflammatory, analgesic, and antitumoral<br>Insecticide (Shah et al. 2011)  | Cough, headache, fever, etc.                       |
| Plant 4                        | <i>Zingiber officinale</i><br>Roscoe / Zingiberaceae | <i>Gingembre</i>                                | <i>Cocobianco (Bulu)</i><br><i>Ndjindja (Ngoumba)</i>   | 43125/NHC                  | Rhizomes: starch; oleoresin; essential oil; proteins; vitamins; mineral; gingerols; zingerone; esters (Emmanuel et al. 2021)   | Anti-inflammatory<br>(Mustafa and Srivastava 1990)  | Flu, fever, headache, dry cough, sore throat, etc. |

## Discussion

### Ethnomedicine

The results of Tables 1, 2, 3, and 4 could be explained as follows; the male informants could have more knowledge on the most used parts (rhizomes of ginger, fruits of lemon, bulbs of garlic, and leaves of lemongrass) of 4 anti-COVID-19 medicinal plants (*C. limon*, *A. sativum*, *Z. officinale*, and *C. citratus*). As well as on the majority association, which is that of 4 plants. And on the infusion, the majority of traditional methods of preparation. This result could be explained by the fact that infusion has more advantages than other traditional preparation methods (Oborah 2022). It is a method in which the active ingredient sought is quickly released into the solvent (a few minutes). It is less expensive regarding materials to use, with instructions accessible to all levels of education. This method requires using easily accessible plant parts such as the leaves (Devgun et al. 2010). In short, the infusion does not contribute to the disappearance of medicinal plants. This considers the mainly used aerial parts, which can regenerate naturally. According to Titanji (2021), all of these results could be explained by the positive contribution of the parts of these medicinal plants to the health of the populations in the study area. Indeed, the parts of all anti-COVID-19 plants used in combination contain secondary metabolites (alkaloids, flavonoids, etc.). These secondary metabolites have therapeutic properties (antimicrobial, anti-inflammatory, etc.), making it possible to treat many illnesses (cough, flu, etc.). Consumption of the combination of parts of these plants would allow the body to fight against foreign bodies such as bacteria, microbes, and viruses while strengthening the immune system.

These plant ingredients would therefore have a protective and fortifying role (Rafieian-Kopaei 2012; Sofowora et al. 2013). Many researchers have studied medicinal plants' protective and fortifying or invigorating role. According to Manvitha and Bidya (2014), the leaves of *C. citratus* have a toning role in the body. Rafique et al. (2020) claim that *C. limon* fruits have a protective role, while Emmanuel et al. (2021) report that *Z. officinale* rhizomes have a protective role. Ammarellou et al. (2022) indicate that *A. sativum* bulbs are invigorating. Thus, combining these plants in the form of syrup by children may benefit them for several reasons. From the fruits of *C. limon*, the human body will benefit from trace elements, vitamins, and fatty acids; the leaves of *C. citratus* will provide humans with tannins, phenolic acids, glycosides, flavonoids, and saponins. The rhizomes of *Z. officinale* will enrich their organism with starch, oleoresin, essential oil, proteins, vitamins, minerals, gingerols, zingerone, and esters. Finally, the *A. sativum* pods will provide them with carbohydrates, proteins, fibers, prostaglandins, vitamins, minerals, trace elements, and essential oils.

The results in Table 4 could also be explained by in-depth studies on each of the different parts of these plants. Botany has contributed to describing and identifying each plant and its different parts (Botineau 2010). Phytochemistry has, for example, made it possible to determine the chemical compounds (alkaloids, flavonoids,

etc.) present in the extracts of the parts of said plants after laboratory studies (Obame 2009). The behavior of the bacterial, microbial, or viral strains in the face of the extracts of the parts of the said plants made it possible to conclude.

Thus, microbiology or pharmacology has made it possible to highlight the antibacterial, antimicrobial, or antiviral activities of the parts of said plants (Loufoua et al. 2015). These in-depth studies justify the uses in traditional medicine (against the flu, colds, coughs, headaches, and fever) reported by informants in the field. Therefore, it could also heal the symptoms of COVID-19, including fever, dry cough, general fatigue, headache, and sore throat (Li et al. 2020)

### Preparing the medicated syrup

Infusion has been a significant traditional method of preparation. This result can be explained by the advantages offered by this method. According to Stéphane et al. (2021), the infusion requires light parts such as the leaves. It is a method of extracting active substances that lasts 10 to 20 minutes. It is simple and very quick to make. However, it has the disadvantages of losing volatile chemicals, degradation of fragile chemicals, etc. The procedure used in this study was to reduce the loss of volatile chemicals from *C. citratus* leaves. Indeed, instead of transferring the boiled water into the container containing the plant matter, which leads to a loss of compounds, the reverse was done. After opening the lid, these plant materials were poured into the boiling water container. *C. citratus* leaves were added last, then the container was closed until cool. This technique reduces the losses revealed by the drawbacks of the process. The choice of the extraction method for the active substances contained in the plants is made according to the duration of extraction, the operating mode, the advantages, the disadvantages, the part of the plants to be used, etc. For example, maceration is another traditional extraction method whose advantages are: simple and less expensive, limiting the release of volatile chemical substances into the air, etc. Its disadvantages are bacterial proliferation, long preparation time, etc. It requires the use of the hard parts of the plant, such as bark, roots, etc. (Rasul 2018; Abubakar and Haque 2020). The "COVID-Med" ITM syrup obtained is a category 2 ITM (MINSANTE 2020) with numerous characteristics. It must be prepared in advance. It must be packaged with a batch number. The raw materials used in its composition are well-known to the population. Its production is made according to methods that guarantee its stability and standardization. If deemed necessary by the competent authority, its safety and efficacy are guaranteed by ethnomedical evidence from long-use experience or open clinical trials. The active ingredients that compose it are raw materials. The main chemical groups of the raw materials are known; stability tests determine their shelf life. For developing countries, ITMs constitute an alternative of primary importance to health expenditure devoted to pharmaceutical specialties imported from industrialized countries (Guedje et al. 2012).

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