ISSN: 2230-9926

Available online at http://www.journalijdr.com

IJDR

International Journal of Development Research
Vol. 14, Issue, 06, pp. 66045-66048, June, 2024
https://doi.org/10.37118/ijdr.28479.06.2024

RESEARCH ARTICLE OPEN ACCESS

ETHNOBOTANICAL INVENTORY AND EVALUATION OF THE DYEING POTENTIAL OF SOME SPECIES OF CONGOLESE FLORA, SOURCES OF NATURAL DYES AMONG THE CRAFTSMEN OF BRAZZAVILLE

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ARTICLE INFO

Article History:

Received 19th March, 2024
Received in revised form
27th April, 2024
Accepted 17th May, 2024
Published online 30th June, 2024

Key Words:

Ethnobotanical Inventory, Dye potential, Congolese flora, Craftsmen.

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ABSTRACT

Extracts from certain plants provide the colouring and binding matter for dyeing. The aim of this study of the dye plants used by craftsmen in the Congo is to characterise the chemical groups with dyeing potential. To achieve this, an ethnobotanical study based on interviews was used to identify the species used by Brazzaville artisans. The ethnobotanical survey of 56 artisans revealed that 38 plant species belonging to 26 botanical families provide various colours that can be used by these artisans. Phytochemical studies of these plants revealed the presence of major groups of chemical compounds such as alkaloids, polyphenols, tannins, flavonoids, anthocyanins, quinone derivatives and coumarins, which are responsible for their dyeing properties.

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Citation*: *Aimé Bertrand Madiélé Mabika, Arnaud Murphy Elouma Ndinga, Longin Justin Clair Bonazaba Milandou, Victor Kimpouni, Mbedi Mpingui and Jean-Maurille Ouamba, 2024. *"Ethnobotanical Inventory and Evaluation of the Dyeing Potential of Some Species of Congolese Flora, sources of natural Dyes among the Craftsmen of Brazzaville". International Journal of Development Research*, 14, (06), 66045-66048.

INTRODUCTION

Dyes derived from natural materials such as plant leaves, roots, bark, insect secretions, and minerals were the only dyes available to mankind for textile dyeing until the first synthetic dye was discovered in 1856. Also, since time immemorial, "Men of all civilizations spread throughout the world have used dyeing substances to color their fabrics and works of art," notes Jean Dorst of the Academy of Sciences, in the preface he wrote in the books by D. Cardon and G. Chatenet, Guide des teintures naturelles (1990, 2000). The Congolese flora is endowed with many plants whose centuries-old use has enabled science to discover important sources of molecules that are now used in the pharmaceutical industries as active agents, in the agri-food industries as spices or dyes, etc. However, it should be pointed out that the field of natural dyes has not been sufficiently explored and still needs to be developed. Several plants have been used traditionally for their coloring properties. In the Congo, the ethnobotanical studies carried out by Adjanohoun and *al*. (1988) and those carried out by Bouquet (1972) on cultivated and spontaneous plants have focused on identifying only medicinal species. But dye plants and their forms of use by the Congolese populations have not been reported. The observation of objects from the past and those of present life shows that craftsmen have used dyeing plants, also in various materials, both in the case of utensils of daily life and in that of ceremonial attributes or ritual life. Over the past twenty years, there has been a growing global interest in natural dyes, not only among traditional craftsmen but also in the fields of textile conservation, the production of paints and pigments, and the cosmetics and food industries (Hnawia and *al*., 2010). In addition, the study of dye plants in Congo is a nascent field of research. The general objective of this study is to present the traditional uses of the colour produced from the Congolese flora used by craftsmen (sculptors, basket makers, weavers, art painting makers) in Brazzaville in order to examine their dyeing potential.

MATERIALS AND METHODS

Presentation of the study area: The study was conducted in Brazzaville, the capital of the Republic of Congo. Brazzaville is located on the banks of the Congo River.

Table 1. Inventory of dye plants used by craftsmen in Brazzaville

Families	Genus and species	Degree of use (%)	Part used	Preparation	Results	Dye uses
Anacardiaceae	*Mangifera indica L.*	28,95	Leaves	Decoction+ mordant	Mist-yellow dye	Raffia and mat dyeing, basketry
Annonacea	*Annickia chlorantha Oliv.*	68,42	Bark	Décoction+ mordant	Yellow dye	Dyeing mats, art paintings, basketry, pottery, masks
Asclépiadaceae	*Cryptolepis sanguinolenta Schltr.*	13,15	Stem	Decoction	Yellow dye	Fibre dyeing, ceramics, sculpture
Astéraceae	*Bidens pilosa* L.	7,90	Leaves /Root	Decoction	Yellow dye	**Fibre dyeing, ceramics, sculpture**
Bombacaceae	*Ceiba pentadra* (Linn.) Gaertn	7,90	bark	Decoction	Black Dye	Fibre dyeing, Basketry
Bignoniaceae	*Stereospermum Kunthianum* Cham.	10,52	Bark	Decoction	Red Dye	Sculpture, basketry
Bixaceae	*Bixa orellana* L.	71,05	Seed	Pressing/Kneading/ grinding	Red pasty material	Fibre dyeing and various masks
Clusiaceae	*Symphonia globulifera* L.	60,52	Bark/latex	Decoction	Yellow dye	Fibre and leather dyeing, Basketry, Art paintings
Combretaceae	*Anogeissus leiocarpa* (DC.) Guil. & Perr	55,26	Leaves / résine	Grinding/decoction + mordant	Yellow dye/brown dye	Dyeing of fibres and leather, gum used in sculpture (coating)
	Combretum glutinosum Perr ex DC.	31,58	Leaves	Decoction	Brownish-yellow dye	Fibre dyeing, basketry
	Terminalia superba Engl. Et Diels	15,79	Bark	Decoction + mordant	Black Dye	Fibre dyeing, basketry, masks
Ebenaceae	*Diospyros heterotricha* F . White	52,63	Stem/Root	Maceration/ décoction + mordant	Orange-yellow dye	Fibre dyeing, raffia, basketry, art objects
	Diospyros geletti De Wild	18,42	Leaves	Decoction +mordant	Red Dye	Fibre dyeing, raffia, basketry, art objects
Euphorbiaceae	*Erythrococa Chevalieri* (Beille) Prain	18,42	Leaves	Decoction	Blue Dye	Raffia, mats and objets d'art
	Alchornea cordifolia Mull	28,94	Bark/ Leaves	Decoction + mordant	Black Dye	Fibre dyeing, pottery, art objects, tattooing
Fabaceae - Cesalpiniaceae	*Griffonia physocarpa* Baill	13,15	Leaves / root	Decoction + mordant	Black Dye	Fibre dyeing, raffia, basketry, art objects
	Piliostigma thonningü (Schm Milne-Redhead)	13,15	Bark	Decoction	Red-brown dye	Fibre dyeing, raffia, basketry, art objects
	Pterolobium stellatum (Forssk.) Brenan	13,15	Bark/Leaves	Decoction	Red Dye	Fibre dyeing, raffia
Fabaceae - Faboïdeae	*Flemingia grahamiana* Wight	10,53	Fruit	Pressing with lemon	Purple or brown dye	Fibre dyeing, raffia
	Indigofera tinctonia L	47,37	Plant (stem and Leaves)	Pounding and infusion in fermented urine	Blue Dye	Textiles
	Macuna poggei Taub	18,42	Leaves/ stem	Decoction	Black Dye	
	Pterocarpus soyauxii taub	81,58	Wood/ Resin	Long decoction in Potash	Red-brown dye	Ritual ceremony, masks, basketry
Hypericaceae	*Harungana madagascariensis* Lan ex poir	68,42	Bark	Decoction + mordant	Yellow-purple dye	Fibre dyeing, raffia, basketry, art objects
	Vismia rubescens Oliv	7,90	Leaves	Decoction + mordant	Blue Dye	Fibre dyeing, raffia, basketry, art objects
Lamiaceae	*Vitex madiensis* Oliv	21,05	Fruit	Pressing + mordant	Black dye	Fibre dyeing, basketry
Lythraceae	*Lawsonia inermis* L	84,21	Leaves	Grinding with lemon	Red-brown dye paste	Raphia and mask, tattooing
Malpighiaceae	*Acridocarpus Congolensis*	34,21	Root bark	Décoction	Brick-red dye	Fibre dyeing, raffia, basketry, art objects
Moraceae	*Bosquiea angolensis* Ficalho	28,98	Latex	Grinding	Red Dye	Basketry
Myrtaceae	*Syzygium jambos*	15,79	Bark	Decoction	Red Dye	Fibre dyeing, raffia, basketry, matting
Olacaceae	*Strombosia grandifolia* Hook. F.	7,90	Latex	Grinding	Black Dye	Pottery
Onagraceae	*Ludwigia leptocarpa* (Nutt.) H.Hara	13,15	Leaves	Decoction	Black Dye	Sculpture, ceramics
Phytolaccaceae	*Phytolacca dodecandran* L'Hér	36,82	Fruit	Decoction	Purple Dye	Fibre dyeing, raffia, basketry, art objects
Phyllanthaceae	*Bridelia ferruginea* Benth	79,95	Bark	Decoction/infusion/ decoction + mordant/ pounding and maceration	Brown dye/dark khaki/black dye bath	Pottery and fibre. Dye bath for mask making
	Hymenocardia acida Tul	65,79	Bark	Infusion + mordant	Reddish-brown dye	Raffia and matting, pottery
Rubiaceae	*Craterispermum schweinfurthii* Hiern	10,53	Wood/ Bark / Leaves	Decoction	Yellow-brown dye	Fibre dyeing, raffia, basketry, cosmetics
	Morinda lucida Benth	18,42	Leaves/ Wood/ Root	Decoction	Yellow or red dye	Fibre dyeing, basketry
Verbanaceae	*Tectona Grandis* L	71,05	Young leaves (buds)	Wrinkle/Grinding /decoction	Red Dye	Cosmetics, art object dyeing, fibres, raffia
Zingiberaceae	*Curcuma longa* L.	84,21	Rhizome	Grinding/decoction	Yellow dye	Raphia, pottery, masks and ceramics, basketry

Brazzaville is 506 km inland from the Atlantic Ocean and about 474 km south of the equator. Around Brazzaville are large plains. The terrain is relatively flat and located at an altitude of 317 m. Its climate is humid sub-tropical (Vennetier, 1966). Brazzaville offers a very green landscape, composed of various species, both in the streets and in the residential plots. Its centre is home to a natural forest known as "crow's feet". It is this landscape that has earned it the nickname "Brazza the green". Brazzaville offers its visitors an interesting range of cultural discoveries: its ceramics, basketry and sculpture workshops, where you can buy statuettes, wooden Teke masks, paintings, raffia textiles and much more. These objects coloured with natural dyes are preferred by environmentally conscious consumers.

Ethnobotanical inventory: The ethnobotanical study took place from March 2021 to September 2023. Fieldwork, ethnobotanical surveys and outings to prepare samples were carried out in all seasons so that samples of perennial and annual plants were available. The survey technique used was based on interviews and observation. In principle, it consists of a face-to-face conversation between two people, one of whom passes on information to the other. The respondent explains the art of using dye plants. Most of the plants used by the respondents were identified in the field compared to the work of Jansen et al (2005), and confirmed in the herbarium of the National Institute for Research in Exact Sciences (IRSEN). The people interviewed are only craftsmen. A total of 56 craftsmen participated in these surveys.

Determination of the degree of use of the dye plants inventoried: The species best known and used by the craftsmen were determined using a quantitative methodology proposed by the Tramil group in the Caribbean (Robineau, 1989). This method considers as plants with a high frequency of use those cited by at least 20% of respondents.

subjected to a binary logistic analysis in order to extract the coefficient of determination in order to assess the effectiveness of the results obtained.

Calculation of the coefficient of determination

The coefficients of determination were calculated according to R^2 of Cox and Snell, Nagelkerke and McFadden.

The R2 are obtained according to the following formulas:

R^2 of Cox et Snell : $R^2_{CS} = 1- (L_0/L_1)^{2/n}$
R^2 of Nagelkerke : $R^2_{N} = 1- (L_0/L_1)^{2/n}/1- L_0^{2/n}$
R^2 of McFadden. : $R^2_{McF} = 1 - [\ln(L_1)/\ln(L_0)]$
With : L_0: Likelihood of the so-called null model
L_1: Likelihood of the calculated model
n: number in the dataset

RESULTS AND DISCUSSION

Ethnobotanical inventory: The analysis of the 56 ethnobotanical surveys led to the census of 38 species of dyeing plants, divided into 26 families as shown in Table 1. Of these, 32 are wild or spontaneous (84.42%) and 6 are cultivated (15.78%). The leaves and bark are mainly used. Most of the dye plants listed are already known to be sources of dyes (Jansen et *al*., 200). Various parts of these plants provide dyes that can be used by craftsmen, and the dye species listed are used mainly in basketry to dye fibres, raffia and mats; to a limited extent in the production of dyes for pottery, sculpture and masks; and

Table 2. Phytochemical screening results

Genus-species/organ used	Chemical groups								
	Al	Poly	T	Tc	Tg	Fl	Ant	dQ	cou
Acridocarpus Congolensis (Root bark*)*	-	+	+	+	+	+	-	+	-
Alchornea cordifolia Mull(Bark)	+	+	+	+	+	+	-	-	-
Annickia chlorantha Oliv. (Bark)	+	+	+	+	+	-	-	-	-
Anogeissus leiocarpa (DC.) Guil. & Perr (feuilles)	-	+	+	+	-	+	-	-	-
Bixa orellana L. (graines)	-	+	+	+	+	+	-	-	-
Bosquiea angolensis Ficalho (latex)	-	+	+	-	+	+	-	+	+
Bridelia ferruginea Benth (Bark)	-	+	+	+	+	+	-	-	-
Combretum glutinosum Perr ex DC. (feuilles)	+	+	+	+	+	+	-	-	-
Curcuma longa L. (rhizomes)	-	+	-	-	-	+	-	-	-
Diospyros heterotricha F . White (tiges)	-	+	+	+	+	+	-	-	-
Harungana madagascariensis Lan ex poir (écorces)	-	+	+	+	+	+	-	-	-
Hymenocardia acida Tul. (Bark)	-	-	+	+	+	-	-	-	-
Indigofera tinctonia L. (tiges feuillées)	+	+	+	+	+	+	+	-	-
Lawsonia inermis L (feuilles)	-	+	+	+	+	-	-	+	-
Mangifera indica L.(feuilles)	-	+	+	+	+	+	-	-	+
Phytolacca dodecandran L'Hér (fruits)	-	+	-	-	-	+	+	-	-
Pterocarpus soyauxii taub (Bois)	+	+	+	+	+	+	-	-	-
Symphonia globulifera L. (Bark)	-	+	+	+	+	+	-	-	-
Tectona Grandis L. (jeunes feuilles)	+	+	+	+	+	+	-	+	-
Vitex madiensis Oliv (fruits)	-	+	+	+	+	+	+	-	-
Number of compounds	6	19	18	18	17	17	3	4	2

Al: alkaloids, T: tannins, Tc: catechetical tannins, Tg: galic tannins, Poly: polyphenols, Fl: flavonoids,
Ant: anthocyanins, dQ :d quinonic erects, Neck: coumarins, +: positive reaction, -: negative reaction

Phytochemical Screening: The phytochemical analyses focused on the plants most used by craftsmen. This is a qualitative analysis based on staining and/or precipitation reactions. This is carried out according to the methodology described by Houghton and Raman (1998) on plant organs previously dried at room temperature, protected from light, then ground and pulverized using an electric shredder such as Bosch AXT Rapid 2200.

Data processing: statistical analysis: The statistical analysis is carried out using the SPSS version 17.0 software where the data have been subjected to a descriptive statistical analysis "cross tabs" or cross-tabulation of the SPSS 17.0 software in order to determine the distribution of the chemical compounds according to the main colours observed. A chemical compound will be a determining colour when its degree of significance is less than 0.05. These results were then

to a lesser extent in the manufacture of art objects, such as paintings. They are often used as markers in traditional ritual ceremonies, in fetishistic relics to dye the loincloths of witch doctors, and in plaster-lined sculptures supporting various mystical elements. This result is close to that observed by Madiélé (2015) regarding the dyeing use of these same plants. Similarly, various methods of preparation have been listed for the preparation of tinctures (grinding, kneading, pressing, pounding, crushing, infusion, decoction, maceration with the possible addition of mordants, etc.). It is also noted that with regard to dyeing properties, the method of preparation depends on the dyeing use and the results obtained are more noticeable with the addition of mordants (lemon, potash, alum, ash, etc.) or may vary according to the treatment. However, decoction is the most used method of preparation by craftsmen for the production of natural dyes.

Result of phytochemical screening compared to the main colors obtained: Table 2 summarises the phytochemical screening carried out on different organs of the 20 most used plants identified. According to this table, 9 main groups of chemical compounds have been characterized, mainly compounds with dyeing potential. These are alkaloids, tannins (catechetical and gallic), polyphenols, flavonoids, anthocyanins, quinonic derivatives, coumarins. The majority of plants contain polyphenols. Tannins are the most common group. They are found in all selected species, 18 of which contain catechetical tannins and 17 gallic tannins; 15 species therefore have the 2 types of tannins in common. These results show that the dyeing plants listed all have tanning properties and could be used in tanning. Indeed, the conclusions and recommendations resulting from the work carried out by Jansen et *al*. (2005) on dyes and tannins in tropical Africa have admitted that tanning plants in particular also have dyeing properties.

In addition, the flavonoid group and the anthocyanin group are present in 17 and 3 plants, respectively. Quinonic derivatives and coumarins are present in 4 and 2 plants, respectively. In addition, 6 plants contain alkaloids. Indeed, these results confirm the dyeing potential of these 20 selected plants. In view of these results, it is important to note that no single chemical group is specifically of the observed color. This observation could lead us to conclude that chemical families tend to create so-called copigmentation assemblies among themselves that improve their coloring power and tonality. It is also important that the terroir, the climate, the stress conditions are likely to influence the production of secondary metabolites in the plant as well as their quantity, inducing chromatic changes. Subsequently, the results of the phytochemical screening were subjected to a descriptive "cross tabs" analysis and a logical binary analysis associating the chemical compounds with the different colors obtained. The analysis of the results shows that, apart from coumarins, compounds, all other groups of chemical compounds found in the plants analysed contribute to the colour phenomenon.

Extraction of the coefficient of determination: The results obtained show that 93.7% of the variation in the production of colours is explained by all chemical groups according to the Cox and Snell method. D even the Nagelkerke method shows that this variation is 95.1%. The McFadden test, recognized by its power, corroborates these results, and clearly shows that only 74.8% of the same variation is explained by all chemical groups. Indeed, these results confirm that there is a synergy in the determination of colors by chemical groups. This observation corroborates that expressed by Escribano-Bailon et *al.* (1996) concerning a study carried out on anthocyanins where they explain that "anthocyanins tend to create between themselves and/or with other phenolic compounds so-called copigmentation assemblies which improve their colouring power, their tone and their resistance depending on the support.

CONCLUSION

The ethnobotanical survey on the traditional use of dyeing plants among Brazzaville's craftsmen has identified 38 plants. These plants, in addition to the various dyes and resins they present, are also used by the local population for multiple treatments. Phytochemical screening allowed the characterization of the following groups of chemical compounds in the plants studied: alkaloids, tannins, flavonoids, quinonic derivatives and coumarins. The various colours obtained result, according to statistical analysis, from synergies between the chemical groups present in the plant. The results obtained on dye plants are therefore more than encouraging and the study deserves to be continued by identifying the chemical molecules responsible for these colours. In addition, the study of dyeing plants is still in its infancy in the Congo. This study examined the current state of natural dyes and various sustainability issues involved in their production and application.

Acknowledgement: The authors thank the craftsmen, in particular the sculptors, basket makers, and art painting manufacturers of Brazzaville who have shown their unfailing availability for the success of this survey, and this in the interest of the realization of the project of creating a House of Natural Colors in Brazzaville.

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