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State of knowledge and research perspectives of *Sclerocarya birrea* subspecies *birrea*: a review

Hien SATASSA[1*], Traoré LASSINA[1], Guissou Laure Marie KUILPOKO[1] and Anne Lykke METTE[2]

[1] *Department of Training and Research in Science and Technology (UFR/ST), University Norbert Zongo, Koudougou, Burkina Faso.*

[2] *Department of Ecoscience, Aarhus University, C. F. Møllers Allé 4, 8000 Aarhus.*

[*]*Corresponding author; E-mail: satsonhien@gmail.com; Telephone: +226 71515439*

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ABSTRACT

Sclerocarya birrea subspecies *birrea* is an underutilized indigenous fruit tree from sub-Saharan Africa. This literature review aims to provide an overview of the current knowledge about this species and identify research and development perspectives. Google Scholar, Web of Science, ScienceDirect, and Dimensions were used to compile scientific articles, books, and thesis. *Sclerocarya birrea* subspecies *birrea* is well-known throughout its distribution range. Its fruit pulp and seeds are widely used for human consumption, leaves, bark, and roots are valued in traditional medicine. However genetic and phenotypic diversity of this species remains undescribed. The population structure shows that the species is underrepresented in the smaller diameter size classes, indicating a potential future decline. To facilitate conservation and domestication efforts of *Sclerocarya birrea* subspecies *birrea*, further research is needed to assess the species varieties included local knowledge, as well as, regeneration potential, fruit yield, and commercialization potentials.

Keywords: *Sclerocarya birrea*, West Africa, Ecology, Morphology.

INTRODUCTION

The *Sclerocarya birrea* subspecies *birrea*, is an important fruit tree species in arid and semiarid savannas in sub-Saharan Africa. It contributes to health, nutrition and food security and is a well-known indigenous plant in Western, Central, and Eastern Africa (Hall et al., 2002; Gouwakinnou et al., 2011a). The species grows in hot, dry climatic conditions with a mean annual rainfall of 200-1500 mm (Shackleton, 2002). It prefers well-drained soils, but also thrives on other types of soils, such as deep granite sands and basaltic clays (Mokgolodi et al., 2011). Female trees produce edible fruits with oil-bearing seeds. The seed oil is traditionally extracted by women through labor-intensive multiple-step processes (Lykke et al., 2021). Tree bark, roots and leaves are used for traditional medicinal purposes (Cheikhyoussef et al., 2011).

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Sclerocarya birrea is underutilized in West Africa. It is kept at varying densities in agricultural fields and homestead plots. However, it can also be integrated into agroforestry systems. Despite its ecological function, there is no domestication initiative due to its low commercial gain in this region. *Sclerocarya birrea* stands are facing overexploitation due to agricultural practices and a low rate of natural regeneration (Gouwakinnou et al., 2009; Daldoum et al., 2012). Trees in farms provide additional income sources and greater resilience strategies for rural farmers. A female tree of *Sclerocarya birrea* can yield up to 416.6 kg of fruits (Shackleton et al., 2003). Effective management and conservation efforts are crucial to ensure sustainable utilization and integration into policies for habitat restoration and economic development. Therefore, it is necessary to assess the current state of knowledge and clarify aspects that remain less understood.

This study aims to provide a literature review of existing information on *Sclerocarya birrea* subspecies *birrea*, including botanical description, ecology and geographical distribution, traditional knowledge, local uses, fruit yield, economic importance, genetic and phenotypic characteristics, propagation and conservation measures to identify possible areas for research.

PROTOCOL OF DATA COLLECTION

This review covers scientific articles (published between 2002 and 2022) on *Sclerocarya birrea*. Data were compiled from Web of Sciences, Google Scholar and Dimensions. The search strategy used keywords and specific expressions: *Sclerocarya birrea*; *Sclerocarya birrea* + West Africa; ecology + *Sclerocarya birrea*; uses patterns + *Sclerocarya birrea*; fruit yield + *Sclerocarya birrea*; domestication + *Sclerocarya birrea*; genetic variation of *Sclerocarya birrea*; propagation of *Sclerocarya birrea* and conservation of *Sclerocarya birrea*. Based on a literature review, we found 201 original articles, books and theses. This review includes 60 scientific articles published only on *Sclerocarya birrea* subspecies *birrea*. Review articles are excluded as well as those published in predatory journals.

BOTANICAL CHARACTERISTICS

Taxonomy of *Sclerocarya birrea*

Sclerocarya birrea (A. Rich.) Hochst. is one of the two species of the genus *Sclerocarya*. The second one *Sclerocarya gillettii* Kokwaro, is endemic to central and eastern Kenya (Hall et al., 2002). Based on morphological characteristics, three subspecies of *Sclerocarya birrea* are recognized: subspecies *birrea* in west, north-east and east tropical Africa; subspecies *multifoliolata* (Engl.) Kokwaro in mixed woodland and wooded grassland in Tanzania and Kenya; and subspecies *caffra* (Sond.) Kokwaro in South Africa.

Species description

Sclerocarya birrea is a dioecious tree that can reach 9-17 m (occasionally 18 m) in height (Figure 1). When isolated, it has a rounded, spreading leafy crown and a short bole (up to 4 m tall) (Bationo-Kando et al., 2008). When young, it has a smooth grey bark, which becomes cracked grey bark for mature trees (Shackleton, 2002; Arbonnier, 2009). The tree is deeply taprooted (down to 30 m). The leaves are borne in clusters at the apex of stout branchlets, and are alternate, 8-38 cm long imparipinnate, bearing 3-18 pairs of opposite or subopposite leaflets (Hall et al., 2022). The leaflets are round to oblong-elliptical or elliptical, 1-9 cm × 0.5-3.5 cm. The limb is glabrous, round to oblong-elliptical or elliptical, dentate-serrate in shape, 1-9 cm long × 0.5-3.5 cm broad. The male inflorescences are terminal or axillary, drooping raceme 5-22 cm long, with 3-4 groups of flowers (Figure 2b), and the female inflorescences are reduced, subterminal spikes with 1-3 flowers (Diallo et al., 2006; Figure 2a). The flowers are small, shortly pediculate, whitish purple to red. The fruits are obovoid fleshy and juicy drupes, 2-3.5 cm in diameter, green becoming yellow at maturity with a weight of 18-35 g (Figure 2c). The flesh surrounds 1-4 oily seeds, 2.5-3 cm in length × 1.5-2.5 cm width (Arbonnier, 2009; Figure 1d,e,f).

Origin, ecology and biogeography

The genus *Sclerocarya* is endemic to Africa and has been introduced to Australia, India (Tamil Nadu), Israel, Mauritius, Oman and Réunion (Hall et al., 2002). The three recognized subspecies occur at nearly exclusive geographic scales, but all are found in northern Tanzania, which constitutes the Southern limit for the subspecies *birrea*. Among all, the subspecies *birrea* appears to be the most geographically widespread (Figure 3). It occurs in West Africa, northern Cameroun, Sudan, Tanzania and northern Kenya (Betti and Yefema'a, 2011; Gouwakinnou et al., 2011c; Daldoum et al., 2012). The *Sclerocarya birrea* subspecies *birrea* is found at sea level in Western Africa and up to 2000 m altitude in Eastern Africa (Kenya, Tanzania) (Hall et al., 2002). It occurs across a range of vegetation types, principally mixed deciduous woodland, wooded grassland and through the open dry savannas of northern Tropical Africa and the Sahelian region (Nyoka et al., 2015). Adapted to 22-29°C mean annual temperature, it is ecologically associated with lithosoils; ferruginous and tropical eroded soils. The subspecies is also found on degraded soils to the most degraded ones (Abdourhamane et al., 2017). However, it was not found in permanent or quasi-permanent flooded areas or on hydromorphic soils. In West Africa, it is maintained in homestead plots, agroforestry systems, natural woodlands and protected areas (Gouwakinnou et al., 2009). The species' adaptability to diverse climates and soils underscores its ecological resilience, presenting opportunities for sustainable land management.

Phenology

Sclerocarya birrea is mainly dioecious. The male and female flowers grow on separate trees. The male flowers are dark red at the bud stage and white when open, whereas the female ones are blood-red in the bud and white reddish-purple when open (Bationo-Kando et al., 2016a). Although some trees with male flowers may bear a few female flowers (Diallo et al., 2006). Overall, there is overlap between provenances and sex about flowering time and this permits cross-pollination without the need to collect, process and store pollen in a breeding program (Msukwa et al., 2019). *Sclerocarya birrea* exhibits various phenology behaviors, e.g. leafing, flowering and fruiting. However, temperature and rainfull are the main factors that influence the phenology of the species (Sene et al., 2020). In the Sahel region, *Sclerocarya birrea* flowers from February to March, triggered by the increase of air humidity, and fruit occurs from April to June (Arbonnier, 2009; Muok et al., 2011). The same observations were reported in Sudan (Abdelkheir et al., 2011). Some trees were found to flower earlier from October to December, and the fruiting occurs in February in Senegal (Sene et al., 2020), whereas late genotypes found in Tanzania started flowering from August to January, and fruiting occurs from September to May (Msukwa et al., 2019). Additional research is needed to better understand the phenology of this species.

TRADITIONAL KNOWLEDGE AND LOCAL USES OF *SCLEROCARYA BIRREA*

Fruit

Sclerocarya birrea fruit is well known for its multiple uses, including animal and human feeding (Table 1). Nutritional applications have been reported in Africa by local populations. The pulp is eaten fresh or used to make local juice or fermented to prepare an alcoholic beverage in West Africa (Gouwakinnou et al., 2011a; Bationo-Kando et al., 2016a; Moussa et al., 2022). The nutrient analysis showed that pulp juice contains 180 mg of vitamin C per 100 g of fresh pulp, approximately 2-10 times higher than the content in lemon, orange and mango (Glew et al., 2004; Bationo-Kando et al., 2009). The biochemical characterization of the pulp shows energy value of 382.68±7.56 Kcal (Halidou et al., 2022). Fruits are used to feed sheep, goats, pigs and wild animals (Mthiyane and Mhlanga, 2017; Kamanula et al., 2022). The *Sclerocarya birrea* subspecies *birrea* fruit has high potential uses and industrial purposes that remain to be explored in West Africa.

Seed

Sclerocarya birrea seed usually contains 2-3 edible kernels (Hall et al., 2002). However, the number of kernels per seed varies

between 0-4, even within the fruits from the same tree (Leakey, 2005). This indicates a potential variation in pollination success alongside genetic differences (Bationo-Kando et al., 2012). The kernels are eaten raw, crushed to make cakes, and oil is extracted for domestic uses (Muok et al., 2011). The *Sclerocarya birrea* subspecies *birrea* seed have high oil content (40-53%) (Robinson et al., 2012) and high oleic acid concentration of (50-63%) (Glew et al., 2004) compared to the two other subpecies *caffra* and *multifoliolata* seeds (Kamanula et al., 2022). In addition, *Sclerocarya birrea* subspecies *birrea* exhibits good physicochemical properties in terms of moisture contents (0.76%), free fatty acid composition (4.07%), acid value (8.13%) and peroxide value (3.02 meq.KOH/g) (Kamanula et al., 2022). Despite this high amount of oil content, *Sclerocarya birrea* subspecies *birrea* seed oil is not well characterized as the other indigenous oil trees in West Africa (Krist et al., 2020). However, it is well-suited for fuel additives and biodiesel production (Robinson et al., 2012). Then seed oil production by industrial step-processes could generate income for rural women and enhance international marketing opportunities.

Young leaves

In West Africa, people use young leaves of *Sclerocarya birrea* in the diets of many communities (Table 1). In northern Benin, young leaves are mixed with seasoned dried peanuts to cook a traditional food called "leaf bundle" (Gouwakinnou et al., 2011a). During the shortage period, rural households in Niger cook young leaves as a sauce. Leaves are also used to feed cattle, sheep and goats (Moussa et al., 2022).

ETHNOMEDICINAL USES OF *SCLEROCARYA BIRREA*

The *Sclerocarya birrea* subspecies *birrea* is a medicinal plant used in various African cultures and traditions for health purposes (Table 2). The main plant parts used in ethnomedicinal treatments include bark, roots and leaves, often decocted, infused or direct consumption (Adiza, 2007). The stem-bark decoctions are used to treat various diseases, including diabetes, diarrhea, stomach aches, sore eyes, toothaches, hypertension and ulcers (Table 2). These diseases are frequently treated across Africa, and *Sclerocarya birrea* efficiency has been supported through pharmacological studies (Adiza, 2007; Maiga, 2010). The stem-bark and leaf extracts contain antidiarrheal, antidiabetic, anti-inflammatory, antiseptic, antimicrobial, antihypertensive, anticonvulsant and antioxidant properties (Lamien-Meda et al., 2008; Nguemo-Dongock et al., 2018). Traditional healers recommend crushing the bark and mixing it with water for infusion (Adiza, 2007; Moussa et al., 2022). The bark is also used to treat syphilis, leprosy, rheumatism and gonorrhea when combined with other medicinal plants (Hall et al., 2002; Bationo-Kando et al., 2016a). Fresh leaves are used for direct consumption in cases of indigestion, stomach aches and diarrhea (Adiza, 2007; Moussa et al., 2022) or to stimulate milk production in nursing women (Gouwakinnou et al., 2011a). Other shared health concerns include snake bites, dysentery, bleeding stops and hepatitis. The root-bark is used to treat sore eyes, syphilis, gonococci and bites by venomous animals.

The wood of *Sclerocarya birrea* is used in carpentry for making bowls, veneers, crates, formwork, sculpture, mortars and pestles (Sene et al., 2018; Souley-Kallo et al., 2018). The species provides shade to livestock and forage grasses growing under them. The inner bark yields fiber for ropes and a red-brown dye used in traditional crafts (Souley-Kallo et al., 2018). Overall, *Sclerocarya birrea* traditional uses are similar in their applications across the areas in which it is distributed. Better management strategies are needed for sustainable use of this species in its natural habitats.

CHARACTERIZATION OF FRUIT YIELD AND CASH INCOME OF *SCLEROCARYA BIRREA*

Fruit yield

The growth and fruit yield data of *Sclerocarya birrea* subspecies *birrea* are scanty and often anecdotal. Fruiting occurs in wild trees at 7-10 years, with yield increasing over time (Shackleton et al., 2003). Few studies have reported fruit yield regarding the species ecological habitat. However, there is

significant year-to-year variation in fruiting and yield among provenances (Hall et al., 2002). Number of fruits per tree ranged from 136 to 4,256 in West Africa (Bationo-Kando et al., 2016a), while in Eastern Africa, it ranged from one to 1,228 fruits (Nyoka et al., 2015). In the Nuba Mountains of Sudan, an average of 31,350 fruits were recorded (Daldoum et al., 2012). These findings highlight the potential of *Sclerocarya birrea* as an important fruit tree with commercial domestication prospects.

Economics

There is no organized supply chain for the *Sclerocarya birrea* subspecies *birrea*, and it remains underutilized as a food source. In West Africa, the commercial interest of this subspecies remains weak compared to the subspecies *caffra* in Southern Africa (Wynberg et al., 2003). This is due to a lack of studies that can contribute to the valorization of species products, the promotion of new products and industrial attempts. For instance, fruits or kernels are not marketed in Senegal (Sene et al., 2018). However, few studies have documented commercial gain at a local market level in West Africa. The sale of kernels, fruits, leaves, and beverages from pulp are an income source for rural households. Cash income from leaves and fruit sales can be US$26.82 per year in rural communities in Niger (Moussa et al., 2022), US$0.5 to 3.34 per seller in rural areas, and US$3.34 to US$66.8 per seller in towns in Burkina Faso (Bationo-Kando et al., 2016a). Therefore, it is important to explore marketing opportunities to enhance commercial gain and conservation of *Sclerocarya birrea*.

MORPHOLOGICAL CHARACTERISTICS AND GENETIC DIVERSITY

Morphological characteristics

The variability within the gene pool of the *Sclerocarya birrea* subspecies *birrea* is crucial for its domestication, conservation and future improvements. The Sahelian populations of *Sclerocarya birrea* appear androdioecious, with hermaphrodite flowers (Diallo et al., 2006). Four types of individuals have been distinguished based on sex and flower distribution: female hermaphroditic individuals with monocline flowers, male individuals giving only diclinous unisexual male flowers, male-dominated polygamous individuals bearing mainly diclinous male flowers and a few monocline flowers, and female-dominated polygamous individuals (Bationo-Kando et al., 2016a). Furthermore, local people are aware of sexual dimorphism using bark appearance (Gouwakinnou et al., 2011c). Some studies mention morphological variation based on farmers' perceptions of habitat, tree size, fruit characteristics and leaf size (Bechir et al., 2022). However, this morphological perception is not statistically consistent. Nonetheless, the botanical inventory has determined discriminating morphological descriptors for the species. These include variations in trunk height to the first ramification, tree height, crown diameter, fruit weight, pulp weight, seed weight, fruit length and fruit diameter among the provenances (Muok et al., 2007; Bationo-Kando et al., 2008; Gouwakinnou et al., 2011b). The diverse range of morphological characteristics across its native habitat influences its adaptability. Indigenous communities have developed a nuanced understanding of the tree's phenotypic variation and harnessed it for various purposes. Studies have provided a regional geographic overview of genetic variation in the *Sclerocarya birrea* subspecies *birrea* based on various morphological characteristics.

Genetic diversity

Knowledge of genetic diversity is important for the successful conservation and domestication of the *Sclerocarya birrea* subspecies *birrea*. This species is undomesticated due to a lack of knowledge of its genetic structure throughout its range, which can aid in varietal selection. The *Sclerocarya birrea* subspecies *birrea* is a diploid species with 2n = 2x = 28 chromosomes (Bationo-Kando et al., 2016b) compared with *Sclerocarya birrea* subspecies *caffra*, 2n = 2x = 26 (Zang et al., 2019). The karyotype consists of five mediums, seven small and two very small-sized chromosome pairs (Bationo-Kando et al., 2016b). The level of genetic

diversity with random amplified polymorphisms in DNA markers is closely related to geographic distance, suggesting significant geographic genetic structuring within the species populations (Muok et al., 2007). Studies in Sudan, Burkina Faso and Kenya have revealed variations in random amplified polymorphic deoxyribonucleic acid (RAPD) phenotypes and polymorphisms. For instance, there were 37 distinct RAPD phenotypes among 75 individuals in Sudan (Abdelkheir et al., 2011), 42 RAPD polymorphisms in Burkina Faso (Bationo-Kando et al., 2012), and a total of 32 RAPD phenotypes within a study group of 61 individuals in Kenya (Muok et al., 2007). The diversity of the *Sclerocarya birrea* gene pool within and between countries calls for concerted, organized collection and assessment of superior germplasm building. Understanding the genetic diversity of this species is essential for successful conservation and domestication.

PROPAGATION, AND MANAGEMENT OF *SCLEROCARYA BIRREA*

The *Sclerocarya birrea* tree can easily be propagated by seed, cuttings, and grafting (Hall et al., 2002; Zida et al., 2014). Vegetative propagation is essential for reproduction of plant material, so that the offspring will contain the exact characteristics as the parent material concerning genotype and health status (Muok et al., 2011).

Propagation by seed

Sclerocarya birrea seeds are dispersed through endozoochory (Helm et al., 2011), selfing, insects and wind-mediated pollination (Msukwa et al., 2019). Seeds are semi-recalcitrant and cannot be maintained in a seed bank for long periods (Fridah et al., 2017). A dormancy breaks to increase germination rate is discussed in the literature (Hall et al., 2002). For instance, to reach a germination rate of 70-75%, seeds require a post-maturing period stored for 18 months at 25°C (Gamene et al., 2005). These results are contrary to those reported for untreated seed in open trial conditions, which reached 68.33% in Niger in two weeks of the latent period (Hamidou et al., 2014). Germination rates depend on seed morphological characteristics, pretreatments and provenance (Chirwa et al., 2007).

Propagation by cutting

Sclerocarya birrea can be propagated through cutting, but this method is used less commonly than grafting due to its poor root system (Mapongmetsem et al., 2016). After four months of trial, the root-cutting test showed rooting rates of 12% and 8% for vertical and horizontal cuttings (Zida et al., 2018). The best time for cuttings is between September and March when trees are actively growing. Cuttings should be 10-15 cm in diameter and 2 m in length, planted at a depth of 1 m. Over 70% of mature trees produce root suckers (Zida et al., 2014), suggesting better management requirements for the species.

Propagation by grafting

Sclerocarya birrea trees can also be propagated successfully by grafting (Lamien et al., 2008). Rootstocks must be grown in advance from seed for later grafting. Seedling trees can be grafted when they reach 20 cm and are about pencil size. The slanted cut on the graft wood and that of the rootstock must fit together neatly, and the cambium layer should overlap on at least one side (Soloviev et al., 2004). Grafted trees are usually shorter and bear fruit from the third to the fifth year, while seedling trees usually bear fruit in five to seven years (Nyoka et al., 2015).

Seedling growth and tree management

Seedlings raised in the nursery produce long taproots (Hamidou et al., 2014). If raised in a nursery or taken as wild, the transplanting should be done while the plant is still small. A good size is when the plant has only two leaves (Chirwa et al., 2007). Transplanting bigger seedlings is difficult without damaging the root and slowing down the growth of plant. Survival growth of *Sclerocarya birrea* seedlings ranges above 90% in field trials (Nyoka et al., 2015). A sex ratio of 1:1 has been estimated for *Sclerocarya birrea* (Nghitoolwa et al., 2003; Gouwakinnou et al., 2011c). Thus, half of each

seedlings populations is potentially fruit-bearing female trees contributing to fruit supply. Consequently, vegetative propagation through cuttings or grafting is an alternative to reduce late onset of fruiting. Even though these techniques are very inexpensive and easily assimilated by farmers, they can limit the genetic diversity of *Sclerocarya birrea* resources. To date, planting *Sclerocarya birrea* trees through nursery has not been implemented anywhere within its distribution range. Furthermore, natural regeneration is rarely recruited and, consequently, requires urgent conservation measures.

GAP OF KNOWLEDGE AND RESEARCH PERSPECTIVES

Sclerocarya birrea is a widespread species found in arid, semi-arid and deciduous savannas across East Africa, West Africa and Central Africa (Hall et al., 2002). Widely used in rural areas, it is underutilized compared to the domesticated subspecies *caffra* in Southern Africa (Leakey, 2005). To encourage the domestication of the *Sclerocarya birrea* subspecies *birrea*, it is crucial to understand local knowledge and farmers' preferences. Successful domestication can be achieved through collaboration with regions like South Africa, identifying superior trees, developing efficient propagation and integrating improved germplasms into farming systems (Leakey et al., 2022). Quantitative assessment methods are needed to monitor fruit yield across diverse habitats and develop propagation techniques for ex-situ conservation. The problem of gender imbalance in *Sclerocarya birrea* trees implies that measures should be taken to ensure adequate pollen flow (Diallo et al., 2006). Seed germination trials across different provenances are needed to test adaptation capacity for breeding perspectives. In summary, these knowledge gaps are important for effective conservation strategies for *Sclerocarya birrea*.

Figure 1: Whole tree of *Sclerocarya birrea* species *birrea* (Photo credit, Hien).

Figure 2: *Sclerocarya birrea*: male inflorescence (a), female inflorescence (b), fruits (c), stone (d), shell (h), and kernels (f) (Photo credit, Hien).

Figure 2: Geographic distribution of the *Sclerocarya birrea* subspecies *birrea* (https://www.gbif.org).

Table 1: Food uses of *Sclerocarya birrea* subspecies *birrea.*

Plant part	Use patterns	Bioactives substances	References
Fruit	Eaten fresh, traditional fermented beer, local juice	Polyphenols, flavonoids, condensed tannin, triterpenoids, phytosterols, vitamin C, total phenolics, catechol tannins, caffeic acid, vanillic acid, methanol, ferulic acid, p-coumaric acid	Hall et al., 2002 ; Glew et al.,2004 ; Bationo-Kando et al., 2009 ; Gouwakinnou et al., 2011a ; Niang et al., 2014, Bationo-Kando et al., 2016a ; Mthiyane and Mhlanga, 2017 ; Sene et al., 2018 ; Moussa et al., 2022
Seed (Kernels)	Eaten raw, process to flavor, extract oil	Oleic acid, Catechol tannins, Sterols, palmitic acid, fiber, quercetin glycosides; stearic acid, arachidonic acid, linoleic acid, palmitoleic acid	Gouwakinnou et al., 2011a ; Muok et al., 2011 ; Bationo-Kando et al., 2016a ; Krist et al., 2020 ; Kamanula et al., 2022
Young leaves	Boil young leaves and mix with seasoning (dried peanut extract, red pepper, salt, and others)	Flavonol glycoside, gallic acid, total phenolics	Gouwakinnou et al., 2011a, Lamien-Meda et al., 2008 ; Moussa et al., 2022

Table 2: Ethnomedicinal uses of *Sclerocarya birrea* subspecies *birrea*.

Country	Ethnomedicinal uses	Part used	Method of application	References
Cameroun	Diabetes, diarrhea, intestinal worms, and toothaches	Stem-bark	Decoction orally taken, Infusion drink	Dimo et al., 2007 ; Betti and Yemefa'a, 2011
Ghana	Snake bite, pruritic, pharyngitis, splenomegaly, goiter	Root-bark, stem-bark, eaves	Decoction orally taken, Infusion drink	Achaglinkame et al., 2019
Senegal	Diabetes, stomach ache, fever, ulcer, blepharitis, otitis, constipation, hypertension, anorexia, syphilis, and snakebite	Stem-bark, root/bark	Decoction orally taken, Infusion drink or steam from boiled roots	Dieye et al., 2008 ; Sene et al., 2018 ; Sene et al., 2020
Burkina Faso	Anal fissures/hemorrhoids, ulcer, conjunctivitis, diarrhea, hypertension, tetanus, dysentery,	Stem-bark, leaves	Decoction orally or anally(childreen) taken; Infused drink, rubbed on affected body parts	Lamien-Meda et al., 2008 ; Bationo/Kando et al., 2016

	diabetes, toothache, cough, animal bites (dog, agouti, rodents), indigestion, chronic wounds, stomach ache, vomiting pregnant women, antiseptic for ruminants		(wound), powdered and use as enema	
Niger	Hemorrhoids, diarrhea, snake bite, ulcer, diabetes, hypertension, tiredness, bleeding (woman), skin diseases, urinary infection, indigestion, sexual impotence, syphilis, wound, leprosy, dysentery, hepatitis, rheumatism, gonorrhea, malaria	Stem-bark, root-bark, leaves	Decoction mixed with other plant, powdered and used as enema, infusion drink or steam from boiled roots	Glew et al., 2004 ; Manzo et al., 2017 ; Moussa et al., 2022
Benin	Malaria, stomach-ache, diarrhea, hemorrhoids, cough and tuberculosis, diabetes, toothache, fortify infants, sore eyes; stop itching or insect bite, swelling, gonococci	Stem-bark, root-bark, leaves	Decoction orally taken, take a bath from infusion, recuperate the sap of fresh young leaves and put it on eye	Gouwakinnou et al., 2011a
Nigeria	Diabetes, anti-inflammatory, hypertension, cancer, gastrointestinal infection, diarrhea,	Stem-bark	Infused in brandy and used as both prophylactic and treatment	Omogbai et al., 2016 ; Abubakar et al., 2020
Mali	Cough, stomach ache, fever, boils, diarrhea, diabetes, malaria, hyperglycemia	Stem-bark, root-bark, leaves	Powdered infusion drink, decoction orally taken	Adiza, 2007 ; Maiga, 2010 ; Denou et al., 2016 ; Kamanula et al., 2022
Kenya	Burns, boils, dysentery, diarrhea, fever, rheumatism, ulcers	Stem-bark	Decoction orally taken	Mlambo et al., 2011 ; Muok et al., 2011
Tanzania	Abdominal and stomach pains, colic, gastric and stomach ulcers, wounds, gonorrhea, bilharzia	Steam-bark, leaves	Boiled and orally taken, Extracts leaves sap and orally taken	Hall et al., 2002

Conclusion

This literature review provides an overview of existing research on the *Sclerocarya birrea* subspecies *birrea*. The taxonomy, botanical description and traditional uses of various parts of the species are well-documented. The genetic diversity of *Sclerocarya birrea* offers opportunities for selection and conservation. However, the incorporation of local knowledge into these efforts remains undocumented. Natural regeneration challenges, annual variation in fruiting and commercial interest underscore the need for research to maximize its economic potential. Understanding the population structure of *Sclerocarya birrea* and effective propagation practices are crucial for sustainable management.

COMPETING INTERESTS

The authors declare that they have no competing interests.

AUTHORS' CONTRIBUTIONS

The authors confirm contribution to the paper as follows: study conception and design: HS and GLMK; data collection analysis and interpretation of results: HS and ALM; draft manuscript preparation: HS and TL. All authors reviewed the results and approved the final version of the manuscript. All authors have read and agreed to the published version of the manuscript.

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