ALLANBLACKIA SEED OIL: HISTORICAL USES AS FUNCTIONAL FOOD, CURRENT USES AND ITS PHYSICOCHEMICAL PARAMETERS

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ABSTRACT

The consumption and commercial exploitation of Allanblackia (clusiaceae) seed oil is of current interest. The favourable physicochemical characteristics of Allanblackia seed oil (solid at room temperature, high stearic acid 50 – 52%, oleic acid 39 – 45% and palmitic 2 – 3% of triglycerides family). It was lend food product that contain vegetable-based dairy products ice cream, spreads health advantages over. Others that contain higher levels of lavric myristic and palmitic acid which can increase blood cholesterol levels. Such considerations are important for individuals' prove. To cardiovascular disease or with hyper cholesterolemia, domestication projects of several Allanblackia species in tropical Africa are under way, but wild crafting of fruits to meet the seed demand still occurs. Proper species authentication is important, since only authenticated oil can be deemed safe for human consumption. The chemical constituency of Allanblackia seed oils and potential roles of these phytochemical in preventive strategies (e.g. as part of a healthy diets) and as pharmacological agent used to treat chronic disease were examined in their review. The primary and secondary metabolic constituency of the seed oil of nearly all Allanblackia specie is still poorly known. The pressure, identity and quantity of potentially bioactive secondary metabolites in the seed oil, and pharmacological testing of isolated compounds were identified as important direction for future research.

Keywords: Allanblackia, closiaceae, seed oil, functional food saturated fatty acid, stearic, oleic and palmatic acids.

Introduction

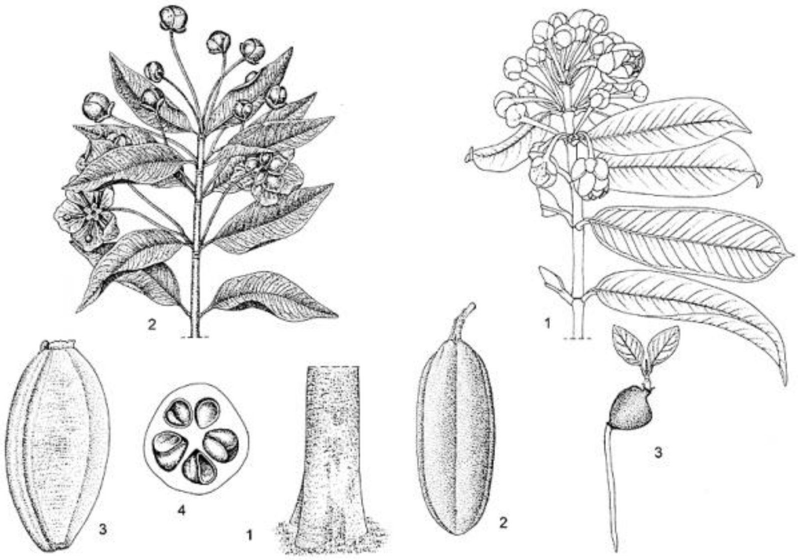
On a worldwide scale, the supplies and consumption of oils and fats have generally been described in terms of 17 commodity oils, four that originate from animals and thirteen that are derived from plants, namely soybean, palm, rape/canola, sunflower, coconut, palm kernel, cottonseed, groundnut (peanut), olive, corn, sesame, rice bran, and flaxseed oil. During recent decades, as information about the negative health effects of animal fat consumption has accumulated, higher consumption rates of fats and oils from plants have been documented. In addition, the demand for oils and fats from alternative plant sources has steadily increased, driven by several factors including: the demand for food from a steadily growing population with more financial resources, demand for biodiesel (food-fuel debate), price increase of some oils due to the rising costs of agricultural production, storage, and transport, fluctuations in oilseed yield due to poor climatic conditions in many parts of the world, and speculation. In particular, due to the fact that more than 90% of the world's biodiesel is currently produced from edible vegetable oils, significant research efforts are being invested in the discovery of alternative plant-based oil (both edible and non-edible) sources.

At the same time, an ever increasing number of consumers believe that foods contribute directly to their health and this has, in turn, driven food producers and manufacturers to produce foods that not only satisfy hunger and provide valuable nutrients, but can be used as preventative medicine to improve both physical and mental health. The World Health Organization (WHO) and the Food and Agriculture Organization of the United Nations (FAO) have described diets and lifestyle habits that can contribute to the development of such chronic diseases as cancer, osteoporosis, coronary heart disease, obesity, periodontal disease, and type 2 diabetes. Therefore, changes in diet and potentially the inclusion of functional foods could lead to the prevention of chronic diseases. As a growing market, functional foods have steadily increasing economic importance. With regard to plant-based oils as functional foods, information on both the primary (i.e., triacylglycerols and fatty acids) and secondary (e.g., phosopholipids, sterols, tocopherols, carotenoids, phenolics) metabolites in these oils is of interest. While numerous reviews about bioactive components in the common commodity oils are available, the literature describing primary and secondary constituents in new, alternative, edible plant-based oils is still sparse. Additionally, few studies have specifically focused on the roles of these phytochemicals in preventive strategies (e.g., associated with increased intake as part of a healthy diet) or as pharmacological agents used in the treatment of chronic disease. The current review summarizes information known about the oils expressed from seeds of species of Allanblackia Oliv. ex. Bentham (Clusiaceae), a genus that is currently the focus of a high degree of attention with regard to its consumption and commercial exploitation.

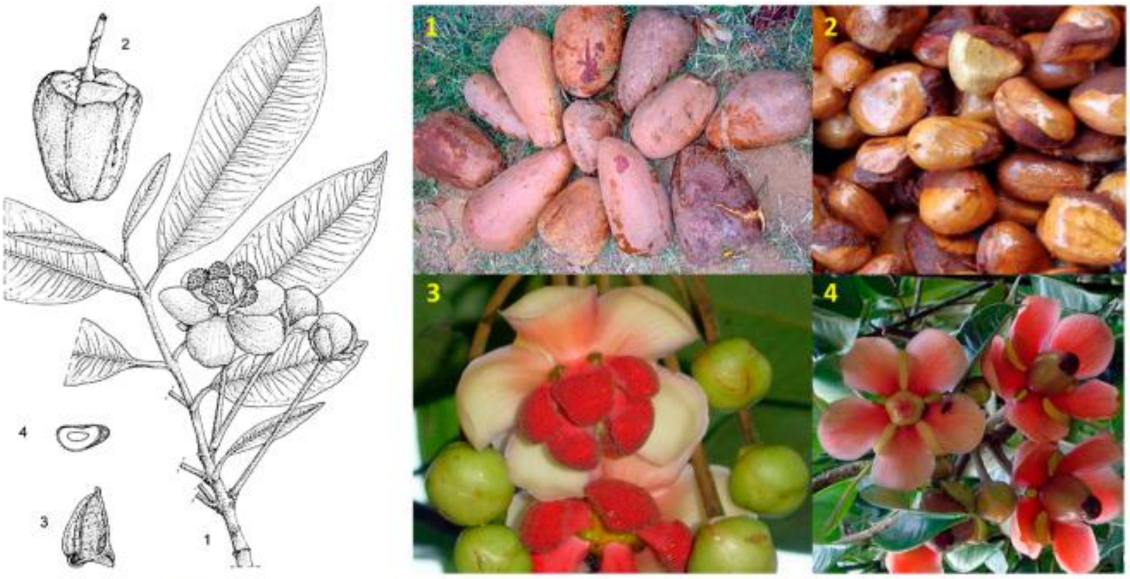
Allanblackia oil is a vegetable oil that comes from the seeds of the Allanblackia tree. This tree can be found in the wet tropical belt of Africa. Because of its unique blend of fatty acids, the oil from Allanblackia seeds has melting properties that make it excellent to use as structuring fat in food products, e.g. margarines.

Currently, Allanblackia seeds are harvested in the wild to produce the oil, but these producers cannot produce enough oil to meet market demand. Finding sustainable ways to increase production could bring many social, environmental, and economic benefits to the communities which produce Allanblackia. To ensure increased production is sustainable and benefits the communities growing the trees, a number of organizations have collaborated to develop a set of standards and methods as guidelines for increasing Allanblackia production. Other organizations are working to establish tree nurseries and other sustainable means of domesticating Allanblackia.

Origin



(a) (b)



(a) (b)

Allanblackia oil is an edible vegetable oil derived from the seeds from the fruits of the Allanblackia tree. This is an evergreen tree producing big brown fruits. Inside those fruits are the seeds that contain the Allanblackia oil.

The genus Allanblackia, which belongs to the Clusiaceae family, consists of nine (possibly ten) tree species, all restricted to Africa. All members of the genus are dioecious (separate male and female trees). There are nine published species of Allanblackia, mostly very similar to each other. The Allanblackia tree is commonly found in the wet tropical rain belt of West, Central and East Africa (from Sierra Leone to Tanzania). It grows primarily in tropical rainforests, but can also be found on cultivated farmland areas. Currently, the most important source of Allanblackia oil is the Allanblackia stuhlmannii tree which is found in the North east of Tanzania in the Eastern Arc mountains Other sub-species are Allanblackia parviflora (Upper Guinea, from Ghana westwards) and the Allanblackia floribunda (Nigeria, Democratic Republic of Congo, Angola). These species occur in moist low-land areas (Allanblackia parviflora, Allanblackia floribunda) or up-land rain forests (Allanblackia stuhlmannii).

The Allanblackia trees are single stemmed, up to 40 meters tall, with whorled branches. The tree will start fruiting at the age of about 8 years and in know to fruit for a long period (likely > 50 years). The fruits of the tree are amongst the biggest of all plants in the African rainforest (particularly Allanblackia stuhlmannii). A fruit can weigh up to 7 kilograms (average 4 kg) of which 20% is wet seeds (40-50 seeds per pod).

Allanblackia Name

The Allanblackia tree was named in honour of the botanist Allan Black (Scotland, 1832). He was the first curator of Kew Gardens and was responsible for the private collection of Charles Darwin. Very respected amongst his peers, he unfortunately died at a young age in Chennai, India and the Allanblackia tree was named in his memory. The name of the Allanblackia tree used by the indigenous people in Tanzania is actually Msambu of Mkimbo in Swahili or sometimes Mkani (Mkanyi, Mkany) in local languages. In Nigeria area of River State, the local name used is Obiobo Obo.

Allanblackia Seed Oil

Composition

The Allanblackia seeds consist of a soft fruit body mesocarp surrounded by hard wooden hull. De-hulled and dried Allanblackia floribunda seeds from Ghana contain up to 70% oil. Taking the weight of the hull into account, the oil content is in the range of 40-50%. Allanblackia seed oil is unusual in that it is composed of only a few triglycerides, derived from palmitic, oleic, and stearic acids. This is similar to other tropical fats like shea and cocoa butter. However, Allanblackia has an unusually high stearic acid content above 50%. More specifically Allanblackia seed oil contains 52-58% stearic acid, 39-45% oleic acid and 2-3% palmitic acid.

A key characteristic is that the fatty acids are organized into a two main triglycerides. These are called 1,3-distearoyl-2-oleoyl-glycerol (abbreviated as SOS at an average level of 69%) and 1,2-dioleoyl-3-stearoyl-sn-glycerol (abbreviated as sn-SOO at an average level of 23%).

This simple triglyceride composition provides the Allanblackia seed oil with very steep melting behavior. This composition makes it useful for making food products such as margerine, without any further modification like fractionation of fractional crystallization. The melting point is around 34 °C. Specific physical characteristics of SOS-SOO mixtures, like fat crystallization aspects, have extensively been investigated in model systems.

Characteristic	Unit	Value
Melting range	°C	42-44
(Slip) melting point	°C	34-35
Solids value - 20 [°C]	%	73.5
Solids value - 30 [°C]	%	46.5
Solids value - 40 [°C]	%	0
Refractive index [60 °C]	-	1,46
Specific gravity [60 °C]	kg/dm3	0.89
Saponification value	mg KOH/g	200
Unsaponifiable matter	%	0.54-0.65
Iodine value	g/100g	35-39

Seed production

The volumes of Allanblackia seeds, and hence seed oil, produced until now very low. The volume of allanblackia seed oil is in the range of 100 metric tonnes per annum only.

These volumes are generated by wild-harvesting mainly done by collectors in Tanzania. When initial studies on the potential of wild-harvesting were done in the early 2000s, the expectations were very high predicting annual production of up to 40,000 tonnes of seeds. In reality only a few tonnes of seeds were harvested in the first year as the number of wild Allanblackia trees that could actually be harvested had severely been overestimated.

Since early 2009, NGOs such as The World Agroforestry Centre (ICRAF), the International Union for the Conservation of Nature (IUCN) and commercial parties have been conducting research programs to investigate the potential to increase the annual production volumes by looking at increased wild-harvesting as well as sustainable domestication of the tree. Through the plantation of the tree with local farmers in Tanzania, Ghana and Nigeria, the production volumes are expected to increase in the coming decade, once these trees are old enough to starting producing fruits and big enough to carry more of the large fruit pods.

Wild Harvesting

Increasing the volumes obviously must be done sustainably and hence socio-economic and environmental aspects are being looked at. For example, the value of Allanblackia as a new cash (annual) crop for Africa means training of local communities not to cut Allanblackia trees for use as timber and firewood. But doing so is also a means of helping to conserve local biodiversity. The Union for Ethical Biotrade (UEBT) has developed a standard and a verification framework against which the sustainability of the Allanblackia supply chain can be audited and approved. UEBT is a member of the International Social and Environmental Accreditation and Labelling (ISEAL) Alliance, which promotes sustainability standards.

Domestication

Wild harvesting as a production method is limited because there are not enough trees to satisfy demand and Allanblackia's flowering and fruiting behavior is erratic. Since 2006, Novel Development Tanzania has been involved in a domestication program together with the World Agroforestry Centre (ICRAF) to domesticate the species using participatory tree domestication approach. The program includes community sensitization, exploration, participatory selections of superior mother trees, conservation in field gene banks, development of agroforestry systems with Allanblackia and market development. Secondly, the program consists of developing asexual and sexual propagation protocols, which are necessary to overcome challenges in multiplication such as seed dormancy, long juvenile phase and high variability of desired traits. The domestication program of Allanblackia through public-private partnership and participatory tree domestication could serve as a model for domestication of other underutilized African tree species of high economic potential.

Oil Production

Seed harvesting and drying

- An individual tree can produce up to 300 fruits a year, with the average bearing 100 to 150 in a good season. In Ghana Allanblackia parviflora fruits have been reported to have a weight of 1.5–2 kg. The fruit pods from the Tanzanian Allanblackia stuhlmannii weigh on average 4 kilogram with a maximum up to 7 kilograms. These may contain up to 40-50 separate seeds embedded in a pulp.
- When the fruit are ripe they will fall down to the ground. Harvesters will collect these fallen fruits and manually extract and clean the seeds. These are then laid out in the sun to dry; this generally takes one to two weeks.

Seed Quality

- After drying the seeds are bagged and brought to collection centers by the farmers / collectors for sale.
- Upon drying the color of the inside (mesocarp) of the seeds will change from off-white (wet) to ocreous-brown (dry).
- In the collection centers this change of color is used to determine the overall quality of drying of each bag of seeds (20–40 kg) by testing a random sample of seeds.
- Next to that seeds are checked for the amount of dirt, while broken seeds are removed. Also seeds infected by insects are removed. Such seeds can be recognized by small holes present in the outer shell of the seeds.
- The seeds collected are put into bags again and brought to a local warehouse waiting to be transported to the oil mill.

Seed and Oil Processing

- From local warehouses the seeds are brought to a central warehouse at the oil mill to press-out the oil. In Tanzania the Allanblackia Oil Mill is in the coastal city of Tanga, in the north-east of the country.
- In the mill the seeds are taken out of the bags and stored locally until crushing. For the crushing a seed-oil press is used, separating the oil from the residual fibrous cake.
- The crude oil is decanted and filtered to remove remaining solids.
- The oil is than stored at 40-45 °C to keep it liquid and pumped to an Iso-container for further transport.
- The remaining cake from the pressing still contains fibers and residual oil] and therefore it is used as a renewable source of energy in the oil mill, generating steam in a high pressure steam boiler.
- After transport to the country where the final product manufacturing will take place, the oil is purified according to standard practices to remove unwanted free fatty acids and off-taste, making the oil ready for use in manufacturing of products, e.g. margarines.

Application in product

Historical Use

In Tanzania the use of allanblackia seed oil goes back almost a century. It has been reported that during the First World War allanblackia oil was already tested as a cocoa butter alternative. Also in the seventies such application was again explored in Europe. However the application never hit the market because larger volumes of the oil were simply not available due to the lack of an organized supply chain.

Nowadays there is still in hardly any local use of Allanblackia seed oil as people prefer use of easily available liquid oils and cheap industrial soaps. The allanblackia tree has predominantly been used for timber in the last decades and hence the number of trees has significantly reduced. Most of the allanblackia trees nowadays remaining in the wild are growing in the East Usambara Mountains which provides the right climate for this tree. As a result, even today the volumes of oil available from wild-harvesting are still very small.

Current Use

The major application potential identified today is in the use as a structuring fat to produce low-trans margarines and dairy cream alternatives, and as cocoa butter equivalent in confectionery applications. In the European Union as of December 2014, all different types of vegetable oils will be listed on the ingredient label of food products using those ingredients. Recently Allanblackia seed oil was introduced in margarine and can be found as such on the product ingredient list.

General Characteristics of the Seed Oil Like many commonly-used vegetable oils, Allanblackia oil consists of well-known triglycerides. Because it contains tocopherol as a minor constituent, it has good storage stability characteristics. Due to its chemical composition and relatively high melting point (ca. 34^0C), it can be used to improve the consistency of cocoa butter substitutes, margarine spreads, and other vegetable-based dairy products. The fact that it does not require additional transformation to acquire the desired characteristics is an added advantage. As in the case of other oils, Allanblackia oil can be combined with other oils or fats to achieve specific physical properties. When analyzing the saturated fatty acids (SFAs), the high stearic acid content (45%–58% on average) and comparatively low palmitic acid content can be used to chemically distinguish Allanblackia oil from palm and palm kernel oils. Allanblackia seed oil shares some characteristics with shea butter (from the seeds of Vitellaria paradoxa C.F.Gaertn. (Sapotaceae), making it a valuable and useful raw material in both the food and cosmetic industries. The triglyceride composition of the seed oil indicates that, given the existence of a stable supply chain, Allanblackia oil can potentially serve as an alternative in many food and cosmetic products to palm oil, cocoa butter, and shea butter. When considering the implications of the use of Allanblackia seed oil as a functional food or functional food component, it is important to keep in mind that individual SFAs have different effects on blood cholesterol levels. Stearic acid is unique in that, unlike other long chain SFAs (>10 carbons), human and animal studies with shea butter and cocoa butter have demonstrated that stearic acid does not alter the levels of total low density lipoprotein (LDL, or “bad” cholesterol) and high density lipoprotein (HDL, or “good” cholesterol) measured in the blood of adults. Other long chain SFAs that often predominate in plant-based oils, including lauric (C12:0), myristic (C14:0), and palmitic (C16:0) acids, lead to increases in blood cholesterol levels and correspondingly increase the risk of the development of cardiovascular disease, unlike stearic acid. These results indicate that including fats and oils (or functional foods containing these) that are rich in stearic acid, as opposed to other SFAs, in the diet could be advantageous, particularly for hypercholesterolemic individuals.

Allanblackia floribunda Seed Oil An early study of A. floribunda seed oil reported that the fatty acid constituents were made up of primarily stearic acid (56.8%) and oleic acid (39.4%), followed by minor amounts of palmitic acid (3.2%), linoleic acid (0.4%), and eicosanoic acid (0.2%). Triglyceride components consisted mostly of 2-oleostearin (76.2%), 1-stearo-diolein (15.5%), and 2-oleopalmitostearin (5%) [39]. In a more recent study, in which seeds collected from seven individuals of A. floribunda growing in the Congo were extracted via Soxhlet extraction (cyclohexane), a yield of 60%–65% oil (w/w) was obtained. This seed oil consisted primarily of a saturated fatty acid (stearic acid, 61%–63%) and a monounsaturated fatty acid (oleic acid, 35%–36%). Another study, in which A. floribunda seeds were collected from trees occurring in Cameroon, ground and extracted using a Soxhlet extraction (hexane) technique, revealed that the seeds contained 62.5% oil (w/w) and 6.7% ash. The oil, examined with gas chromatography, consisted of 62.6% of saturated fatty acids (61.3% of which were stearic acid) and 36.7% of monounsaturated fatty acids (of which 36.6% were oleic acid), as well as 0.7% polyunsaturated fatty acids. Analyses of seeds collected from A. floribunda trees growing in Nigeria yielded similar results, demonstrating that the seeds contained on average 60.4% oil, 1.7% ash, 4.1% fiber, and 32.6% carbohydrates. Positive chemical reactions that indicated the presence of minor amounts of alkaloids, flavonoids, saponins, and tannins were observed, although it must be noted that these results must be confirmed by alternative methods (e.g., TLC, HPLC), since false positive test results can occur with the methods described. While few studies have thus far been conducted to examine intra- and interpopulation differences in

Allanblackia seed oil yield and composition, one such study in which 17–40 fruits were sampled from each of 70 A. floribunda trees growing wild at four sites from within the natural range of the species in Cameroon revealed that the fatty acid content of the seeds ranged from 44.2%–66.1% (stearic acid) and 25.0%–48.4% (oleic acid) among tree samples. Significant tree-to-tree variation in the mass of the fruits, number of seeds in each fruit, and chemical constituents of the seed oil were observed. On one hand, these results allowed the researchers to identify a potential breeding population (trees that produced seeds with desired characteristics), but on the other hand, the high degree of variation in both physical and chemical properties of the fruits and seeds of the wild A. floribunda trees highlights some of the inherent problems encountered when attempting to establish a steady supply chain of high-quality Allanblackia oil from seeds collected in the wild. The optimum conditions for the extraction of seed oil from several species of Allanblackia have yet to be determined. One study, however, has been conducted with A. floribunda seeds to determine the optimum extraction conditions and assess both the quality and stability of the oil obtained from crude pressing methods and from solvent extraction. In this study, the seed samples were milled under different temperature regimes and moisture levels, and the oil was either expressed by use of a manual screw press or a Soxhlet apparatus (solvent: petroleum ether). The oil yield obtained from solvent extraction was higher than from the manual expression (67.6% vs. 48.6%, respectively), but the quality parameters measured such as the melting point, acid value, ester value, iodine value, peroxide value, refractive index, specific gravity, and saponification value showed no significant differences between the oils. The pressed oil, however, due to significant differences in the peroxide value and free fatty acid content, was more stable when stored in plastic containers as compared to the oil extracted with solvent.

While the quality parameters of the expressed or extracted oil are of particular importance, the toxicological and environmental aspects of seed oil extraction also require consideration. The use of hot water as an extraction solvent, due to its low cost, toxicity, and environmental impact, was investigated as a method of extracting oil from A. floribunda seeds. An extraction yield of 42.2% oil (w/w) from the seeds and extraction efficiency of 58.6% was reported by Alenyorege et al., indicating that this method could be applied to meet commercial, industrial, and domestic demands. 2.4.2. Allanblackia parviflora Seed Oil The seed oil from A. parviflora has been shown to be quite similar to that from A. floribunda. An early study of the fatty acid components of A. parviflora revealed them to be primarily stearic acid (51.6%) and oleic acid (43.9%), with minor amounts of myristic acid (1.8%), palmitic acid (2.5%), and eicosanoic acid (0.2%). The major triglyceride component were determined as 2-oleostearin (60.1%), 1-stearo-diolein (26.9%) and 2-oleopalmitostearin (6.9%). A study conducted on seeds of A. parviflora growing in Ghana, from which oil was extracted by either the use of a screw press or Soxhlet extraction (petroleum ether), yielded an average of 68% oil (w/w). The fatty acid composition of the seed oil was determined by gas chromatography as 2.9% palmitic acid, 52.3% stearic acid, and 44.8% oleic acid. Secondary metabolites belonging to the classes of carotenoids, terpenes, saponins, or tannins were not detected in the oil in this study. Nutritional analyses indicated that the seeds contained 4.3% protein, 2.0% ash, 5.7% crude fiber, and 17.1% carbohydrates. These values were generally lower than those reported for shea kernels and cocoa beans, but the energetic value of Allanblackia seeds was 2863.44 kJ/100 g (exceeding both that of shea kernels and cocoa beans), supporting the traditional consumption of these seeds as a high-energy snack in some parts of Africa. Allanblackia stuhlmannii Seed Oil a triglyceride derived from three molecules of stearic acid (2-oleostearin) was first isolated by crystallization from A. stuhlmannii seed oil in 1896, in amounts that were even remarked upon as being impressive at the time. The seed oil of A. stuhlmannii displays some similarities to that of A. floribunda and A. parviflora. The edible oil is solid at room temperature (melting point (mp) = 34 °C) and, in Tanzania, is referred to by the common names "Allanblackia fat" or "kanye butter". Due to its physical properties and neutral taste, it is used in cooking. The seeds have been reported contain ca. 50% oil (w/w), the fatty acid composition of which consists mainly of stearic acid (45%–58%) and oleic acid (40%–51%). Other Allanblackia Seed Oils The seed oils of two species of Allanblackia occurring in Cameroon, A. gabonensis and A. stanerana, have been examined, whereby the oil was extracted through maceration of the ground seeds with hexane. The seeds of A. gabonensis were demonstrated to yield 68.2% oil (w/w), which contained 5.35% water and 60.6% saturated, 37.6% monounsaturated, and 0.8% polyunsaturated fatty acids, of which the C18:0 and C18:1 types dominated. The seeds of A. stanerana, meanwhile, yielded 69.9% oil (w/w), which contained 22.0% water and 70.9% saturated, 28.2% monounsaturated, and 0.8% polyunsaturated fatty acids, and again, the C18:0 and C18:1 types dominated. The quality parameters, namely the acid index, iodine index, and refractive index values, were similar for these two oils, although the former two parameters were higher for A. gabonensis and the latter parameter, higher for A. stanerana. In both seed oils, the primary saturated fatty acid was stearic acid (60.1% and 69.6%, respectively), while the major monounsaturated fatty acid was oleic acid (37.4% and 28.1%, respectively. The seed oils of A. kimbiliensis, A. kisonghi, A. marienii and A. ulugurensis have not yet been subjected to physicochemical or phytochemical analyses to this author's knowledge. 2.5. Phytochemistry and Medicinal Use of Allanblackia Seeds In western Africa, decoctions of the leaves and bark of A. floribunda are used to treat toothache, dysentery, and hypertension and the crushed plant material or extracts is applied topically as an analgesic. Specific medicinal applications for the seeds, however, in the traditional medicinal systems found in this region, and no bioactive secondary metabolites have yet been isolated from the plant. In Tanzania, various parts of A. stuhlmannii are used in the traditional medicine; the leaves are chewed to treat coughs, a leaf tea is drunk to treat chest pain, and extracts of the roots, bark, and leaves are taken to treat impotence. Interestingly, the heated oil extracted from the seeds is used as a liniment to treat rheumatism, rubbed into sore joints, or dabbed on wounds and rashes. The Hehe people, native to south-central Tanzania, have been reported to combine the seed oil with crushed seeds of Psorospermum febrifugum Spach (Hypericaceae) and rub the mixture into the soles of the feet to heal deep cracks. Although no phytochemical investigations of A. stuhlmanniii seeds have yet been conducted, the seeds of Psorospermum febrifugum have been shown to contain numerous bioactive xanthones. Interestingly, a xanthone derivative (allanxanthone E), several xanthones (1,7-dihydroxy-3-methoxy2-(3-methylbut-2-enyl) xanthone; α-mangostin; garciniafuran; allanxanthone C; and 1,6-dihydroxy-2,4- diprenylxanthone) and two triterpenes (friedelin and lupeol) have been isolated from the seeds of Allanblackia gabonensis (cited under the synonym A. monticola Mildbr. ex Engl.), which is widely distributed in western Cameroon. This species is used in the local traditional medicine to treat diarrhea, fever, pain, respiratory infections, and toothache. α-mangostin was shown to possess apoptotic and antiproliferative activity against ESKOL cells derived from a hairy cell leukemia patient and leukemia cells freshly isolated from B-CLL patients when tested in concentrations as low as 2.4 μM. Allanxanthone E, 1,7-dihydroxy-3- methoxy-2-(3-methylbut-2-enyl) xanthone, and α-mangostin triggered apoptosis in B-CLL leukemia cells in a dose-dependent manner, whereby the latter compound was the most potent. These results are significant when considering the inclusion of Allanblackia oils in functional foods, especially unrefined oils and particularly those that have been extracted using solvents with intermediate polarity. As shown for the case of the benzophenone derivatives, guttiferone E and F (Section 2.2), bioactive secondary metabolites can be co-extracted along with primary metabolites such as triacylglycerols and fatty acids from the seeds of Allanblackia. When ingested, these phytochemicals have the potential to act as pharmacological agents, and could prevent the development of or be used to treat chronic disease. This said, very few studies to date have carefully examined either manually expressed or solvent extracted Allanblackia seed oils for the presence, identity and/or quantity of potentially bioactive secondary metabolites, and this is both an interesting and important direction for future research.

3. Conclusions Species of the genus Allanblackia (Clusiaceae) are currently the focus of a high degree of attention, due to interest in the consumption and commercial exploitation of the seed oils. The steadily increasing demand for alternative, plant-based oils and fats and the favorable physicochemical characteristics of Allanblackia seed oils (with up to 95% combined stearic and oleic acid) have led to its inclusion as an ingredient in functional food products, including vegetable-based dairy products, ice cream, and spreads. While domestication projects are underway to establish the sustainable cultivation of several Allanblackia species in tropical Africa, the steadily growing demand for the seed oil has resulted in increased harvesting pressures on wild populations of Allanblackia species and, in turn, increased the risk of misidentification and/or adulteration. Proper botanical identification of the species used is important, since only authenticated oil can be deemed safe for human consumption when included in functional food products. In terms of its nutritional value, Allanblackia oil can be combined with other oils or fats to achieve specific physical properties. The high stearic acid content (ranging, according to the species, between 44%–66%) and comparatively low palmitic acid content of the oil is relevant because stearic acid has not been demonstrated to alter the plasma levels of total low density lipoprotein (LDL, or “bad” cholesterol) and high density lipoprotein (HDL, or “good” cholesterol), unlike palmitic acid. Functional food products containing Allanblackia oil, therefore, could be considered to have health advantages over products containing oils with higher levels of lauric, myristic, and/or palmitic acids, the ingestion of which has been shown to lead to increases in blood cholesterol levels. Such considerations may be particularly important for individuals at greater risk of cardiovascular disease or who have hypercholesterolemia. Information available about the chemical constituency of Allanblackia seed oils, the roles of the component phytochemicals in preventive strategies (e.g., associated with increased intake as part of a healthy diet), or the role of these compounds as pharmacological agents used in the treatment of chronic disease was examined in this review. The phytochemistry of the seed oils of nearly all Allanblackia species is poorly known, particularly with regard to the presence and/or content of lipophilic secondary

metabolites. Unrefined seed oils from Allanblackia have been shown to contain bioactive secondary metabolites (i.e., benzophenone derivatives, xanthones), which may have the potential to act as pharmacological agents when ingested. Phytochemical investigations of Allanblackia seed oils for the presence, identity and/or quantity of potentially bioactive secondary metabolites, and pharmacological testing of isolated compounds represent important directions for future research.

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