International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Impact Factor (2012): 3.358

Castor Oil Plant (*Ricinus communis* L.): Botany, Ecology and Uses

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Abstract: ***Castor (Ricinus communis L.) is a species of flowering plant in the spurge family (Euphorbiaceae) which contains a vast number of plants mostly native to the tropics. It belongs to a monotypic genus Ricinus and sub-tribe Ricininae. Castor plant's origin is obscured by its wide dissemination in ancient times, and the ease and rapidity of its establishment as a native plant. Castor was one of the oldest cultivated crops before being abandoned in many countries in the world. The crop is now widely revived as an agricultural solution for all tropical and subtropical regions, addressing the need for commercial crops with low input costs and viable returns. Castor is a hardy crop, easy to establish on the field, resistant to drought, tolerate different types of soil even marginal soil and yield 350 – 900 kg oil per hactare. Castor is an important oilseed crop with great utilitarian value in industry, pharmaceutical and agricultural sectors. In the last couple of years, demand for castor oil has kept increasing in the international market, assured by more than 700 uses, ranging from medicine and cosmetics to biodiesel, plastics and lubricants. The oil is critical to many industrial applications, compared with other vegetable oil, because of its unique ability to withstand high and low temperatures. This review was conducted to give; (i) a good botanical description of castor (ii) highlight the castor breeding methods and techniques (iii) outline various common pests, diseases and their treatments (iv) discuss detailed ecology and (v) highlight various local and industrial uses.***

Keywords: Castor botany, ecology, industrial uses, castor breeding, pest, disease

1. Botany

Castor plant, *Ricinus communis* L. is a species of flowering plant in the spurge family; *Euphorbiaceae*, which contains a vast number of plants mostly native to the tropics [19]. It belongs to a monotypic genus *Ricinus*. The name *Ricinus* is a latin word for tick. The plant is named probably because it seed has markings and a dump at the end that resemble certain tick [36]. The common name castor oil comes from its uses as a replacement for a perfume base made from dried perinea glands of beaver [39]. The taxonomy of castor is as shown below.

2. Rank Scientific Name Common Name

Kingdom *Plantae* Plants
Subkindom *Tracheobionta* Vascular Plant
Superdivision *Spermatophyta* Seed plant
Division *Magnoliophyta* Flowering Plant
Subclass *Rosidae*
Order *Euphorbiales*
Family *Euphorbiaceae* Spurge Family
Genus *Ricinus* L. Ricinus
Species Ricinus communis L. Castor Seed
(USDA National Plant Database. 2006)

While castor is mostly agreed to be a native to Africa, by cultivation it has been distributed through not only all tropical and subtropical regions, but also in many of the temperate countries of the globe. Castor plant varies greatly in its growth and appearance. It varies in growth habit, colour of foliage, stems, seed size and colour, and oil content, so that varieties often bear little resemblance to one another. Castor may be large perennials often developing into small trees, others behave as short-lived dwarf annuals and every gradation between these extremes can be found. The tree and short-internodes types are commonly referred to as giant and dwarf castor types respectively [37]. However, castor grows at an amazingly fast rate, if they are situated in full sun and provided with ample fertilizer and water.

Figure 1: Picture of a castor plant at NCRI castor field

2.1 Castor Root

Figure 2: A typical dwarf castor root at NCRI Castor Field

Castor plants can be grouped into tall and short types. The tall type has a large, well-developed tap-root which can reach several feet in length and has substantial laterals and secondary roots. Dwarf types roots always reflect peculiarity to particular variety or cultural system and show less apparent tap-root. In arid areas where the plant has only rainfall for subsistence, aerial growth tends to be slower in relation to root growth than under more favourable conditions [37]. The well-developed root system allows the plant to take maximum advantage of soil moisture, a major factor in the plants resistance to drought. Root system shows a strong correlation to yield because it allows the crop to tape necessary nutrient and water for proper accumulation of biomass. Planting castor in a soft and loose soil is an advantage for proper development of root which will in turn contribute to better yield.

2.2 Castor Stem

The castor stem is round, sometimes covered with a waxy bloom which gives red or green stems a bluish appearance on the field. The stem colour may be green, red or purple and every graduations of the colour can be seen. The stem colour generally often turn grey-like colour at the base when the castor is old. The presence of plastids in the stem at juvenile stage gives opportunity for additional photosynthetic activity. Under natural environment, the stem is multi-branched, primary branches giving rise to secondary branches, a sequence that continues over the life of the plant. The stem of dwarf types generally becomes hallow with age, but it is usually solid to a considerable height in giant tree-like types. There are well-developed nodes, from each of which a leaf arises. The node at which the first racemes appear is an important agronomic characteristic, since it is associated with quick maturity. In dwarf-internodes hybrids, it usually occurs after the sixth to twelfth node, but in segregating population can vary from six to forty-five [37]. Pruning to reduce the height or number of major branches has been frequently attempted but is usually ineffective on giant castor, although it may increase yield. The cost of the operation may be greater than the value of increased yield. Topping at 30 – 60 cm can reduce the height and increase the branching, but decrease the yield. At Budo Umaru in Kwara State (Nigeria), the barks of castor plant are being eaten by the goat [21].

2.3 Castor Leaf

The leaves are large, often dark glossy green and about 15 to 45 centimetres long, with long petiole. The leaves are palmate with five to eleven lobes and prominent veins on the under surface. The leaves are alternate, except for two opposite leaves at the node immediately above cotyledons. The leaf colour varies from light green to dark red depending on the level of anthocyanin pigmentation present [36]. In some castors, the leaves start – off as dark reddish purple or bronze when young but gradually changing to a dark green, sometimes with a reddish tinge as they mature. The leaves of some others are green practically from the start, whereas in others a pigment masks the green colour of all the Chlorophyll – bearing parts. Growth and expansion of castor leaves do not appear to be checked by prolonged sunlight provided there is ample moisture for transpiration. It is when a water deficit has been built up that leaf growth and expansion are affected [36]. The reduction in leaf growth and expansion, and drastically falling of leaves during dry season, resulting in low surface area for photosynthetic activity, are the causes of reduction in yield observed during the season. The leaf diseases cause by some bacteria and fungi can also affect the yield.

2.4 Castor Flower

Figure 3: Picture of a typical castor flower at NCRI castor field

Castor can produce flowers over a long period, especially under natural condition when climatic condition is favourable. Castor is naturally a cross – pollinated plant and wind is the major agent of pollination. The castor flowers are borne on inflorescences, which forms a pyramidal raceme also known as spikes, terminally on main and lateral branches. The flowers may be monoecious (male and female), pistillate (female only) or interspersed (arranged intersperse) on the inflorescence [13]. The male flowers occupy the under portion of the spike. They have no corolla but have a green calyx deeply cut into three to five segments enclosing numerous

branched yellow stamens. The female flowers occupy the upper portion of the spike and have likewise no corolla. The three narrow segments of the calyx are, however, of a reddish colour, and the ovary in their centre is crowned by deeply divided red thread-like styles. The inflorescence can reach a length of 100cm, but since there is wide variation in distance between the flowers, ratio of male to female flowers and number of fertile female flowers, the yield is not necessary correlated with the length. In most castor varieties, female flowers open before the male while in others male open first [22]. The male flowers shed most of the viable pollens between 1 to 2 days after opening. The pollens normally shed from 2 - 3 hours before sunrise until late afternoon, and there is frequently a peak at mid-morning. The pollen is shed readily between 26 – 29^{0}C with a relative humidity of 60 percent. The stigma can remain receptive for period of 5 to 10 days after opening [7]. Days between the opening of female flowers and that of male may varies from 3 to 7 days depending on genotypes.

2.5 Castor Fruit

Figure 4: Picture of a typical castor fruit at NCRI castor research field

The fruit is a globular spiny capsule which becomes hard and brittle when ripe. The Castor fruit is usually a schizocarp, typical regma; a capsular fruit with three cells each of which splits open at maturity into separate parts and then breaks away explosively, shattering the seeds. However, some castor varieties produce capsules with rudimentary spines, some produce soft, flexible and non – irritant spiny capsules while other produce spiny irritant capsules. After fertilization, the formation of capsule commenced 3 to 7 days [22]. Racemes can be conical, cylindrical or oval in shape with difference capsule arrangements. The capsule arrangement may be compact, semi-compact or loose [27]. The distance between the capsules reduces the damages cause by the borers. The capsule may vary in colour from light green to wine and every graduation can be found.

The period from seedling emergence to capsules' maturity varies with genotypes. On average, it varies from 140 – 160 days. The lowest flowering racemes usually mature first, the others following in sequence up to the stem. Ripening of fruits along the racemes is sometimes uneven and in some wild varieties the period between first and last mature fruits may be several weeks. The capsules of some varieties shatter at maturity while some do not. In some, the whole capsule falls from desiccated raceme with the seed remaining enclosed. In others, the capsule split to release seeds. The degree of hardness of capsule wall is varietals characteristic. Consequently, strong capsules tend to preclude mechanical hulling while very soft capsule may be difficult to hull without damaging the seeds [27].

2.6 Castor Seed

Figure 5: Picture of Some Castor seeds at NCRI

The capsule contains three seeds which may be elongated, oval or square in shape. The seed has a tiny and brittle testa (seed coat) enclosing a white kernel. The seeds may be coloured white, dark brownish-red, brown, dark chocolate, red or black but usually several colours occur as very attractive mottle on the testa. The seeds vary greatly in size, from a few millimeters to nearly 250mm long and in breadth from 5 to 16mm.100 seeds varies in weight from 9 to 100g [27]. The variation is not only among varieties but from different racemes. In general, the seed weight increases as the total number seeds produced per plant decreases [28].

In some varieties, castor seeds may have a dormancy period of several months while freshly harvested seeds of some can germinate without special treatment. However, large seeded castors often germinate earlier compared with tiny seed [21]. The dormancy in some castor can be broken by soaking for 24hr in water or removing the caruncle and pierce the testa at the site. Germination is epigeal with the cotyledons coming out above the soil and expands as green leaves.

3. Castor Oil Constituents and Seed Danger

Three terpenoids and a tocopherol-related compound have been found in the aerial parts of *Ricinus communis*. The plant oils are typically composed of triglyceride molecules (technically called esters) which contain a 3-carbon alcohol (glycerol) and three 18-carbons (or 16 - carbons) fatty acids. Castor oil is unique among vegetable oils because it is the only commercial source of a hydroxylated fatty acid (ricinoleic acid). The oil contains around 90% of the fatty acid [23].

However, the present of toxic components of castor seed (including the protein ricin and the alkaloid ricinine) have been a concern for all who handle castor seed, meal or oil

extraction factories. The most notorious constituent is ricin, a deadly poison found in abundance in the seed and in smaller amounts throughout the rest of the plant. Poisoning occurs when animals ingest broken seeds or chew the seeds. Intact seeds may pass through the digestive tract without releasing ricin. Commercially available cold-pressed castor oil is not toxic to humans in normal doses, either internal or externally. Symptoms of ricin poisoning begin within hours after exposure by ingestion or inhalation. The symptoms may include stomach irritation, vomiting, bloody diarrhea, abdominal pain, increased heart rate, low blood pressure, profuse sweating, collapse, convulsions, and death within a few days. There are obvious concerns about the use of ricin as a biological weapon.

Nevertheless, growers of castor as both indoors and outdoors ornamental plants may adopt removal of flower clusters from the plant as they appear hence no seeds will be produced, and the risk of accidental poisoning can be minimized.

4. Castor Breeding

Handling castor at a smallholder level, visual selection for desired characteristics is a useful method of producing local superior genotypes. Under more intensive production methods, ultimate objective must be to maximize the oil yield per hectare. Several research institutions and universities around the world are now working on development of viable biodiesel crops, producing castor varieties suitable to the agronomic conditions in their respective countries. Castor breeding programme in developed countries are focusing on problems associated with castor mechanization while other breeding factors can be more important to peasant farmers in developing nations.

5. Castor Breeding Objectives

Presently the main objectives of castor breeding programs around the world are breeding for earliness of seed maturation, mechanized plant architecture and disease resistance. These objectives must be combined with high seed yield and oil content (at least 48%). Searching for castor genotypes with short height (< 1.5m), long and effective primary raceme (20 – 40cm), early harvesting (< 150 days), erect stem and non-shattering capsules are the primary priority of most castor breeding programs [18]. In some, genotypes have been selected for tolerance to drought, high temperature, salinity and exchangeable aluminum. However, reduction in ricin content in the seed is one of the targets for advanced castor programs.

6. Genetics of Important Agronomic Traits

Castor breeding involves adequate understanding of the genetics of its economically important traits. In castor, like in other cultivated crops, primary economic traits like seed yield and seed oil contents are usually inherited in a quantitative manner. Additive genetic effects were shown to be important in determining the number of nodes before flowering, number of racemes per plant, and seed oil content [34]. Trait like length of the primary raceme, number of capsules on primary raceme and the seed weight have been shown to be additively inherited [32]. High heritability was reported for earliness, seed weight and plant height [31]. Stem colour was reported to show epistatic interaction of two genes, ‘M’ (mahogany) and ‘G’ – green [12]. Tall plants are dominant over dwarf plants due to a monogenic factor. Waxy bloom, spike compactness, capsule spines and branching of castor appear to be control by partial dominance and simply inherited [25].

7. Castor Genetic Resources

A total of 12 major sources of castor germplasm and 6,588 castor accessions were identified by International Germplasm Collections on Biodiversity and USDA-ARS castor germplasm at Griffin, GA (USA). These sources are located in Brazil, China, Ethiopia, India, Kenya, USA, Ukraine, Serbia, Romania and Russia. Castor germplasm can also be obtained from public castor breeders in Brazil, Columbia, India and Israel [17]. However, feral castor surviving as weed along roadside in the tropical climate can be a valuable source of germplasm for adaptation to localized diseases, pests and environmental changes. In Nigeria, castor germplasm can be obtained from National Cereals Research Institute (NCRI), Badeggi, Bida.

8. Castor Breeding Methods and Techniques

In castor, the procedures for making artificial crossings and self fertilizations are relatively easy and result in several seeds. The productive biology of castor allows the breeders to successively exploit both the methods used to improve self pollinated crops as well as the recurrent selection mostly used on cross pollinated crops for its improvement.

8.1 Mass selection

Mass selection consists of the selection of superior types and discarding of undesirable types within a population. It is used to improve population or standardize traits of economic importance. Mass selection is most effective method for characteristics with high heritability in populations with high level of natural genetic variability. IAC-38, an important dwarf castor cultivar in Brazil, was developed through mass selection [30].

8.2 Individual plant selection with progeny tests

This method involves selection of individual plants and the subsequent study of their offspring in progeny trails. It is a straight forward procedure to achieve greater uniformity and increased production in castor with high levels of natural genetic variability. This method was successfully used in the development of high yielding cultivar Guarany [2].

8.3 Methods involving sexual hybridization

When populations of castor with sufficient natural genetic variation for agronomic characteristics are not available, it is necessary to generate variability by producing hybrids between different lines or cultivars. The choice of the parents of these populations must be based on their performance within the targeted production region, and if there are many promising parents, diallel cross can be used.

- Pedigree; this method is adequate for simultaneous selection of several traits. This has been used to develop cultivar IAC-2028, a dwarf and non-shattering genotype in Brazil.
- Bulk selection; this method allows segregation of the hybrid population without artificial selection until F_5 or later generation. It is the most effective method of improving adaptation of castor to drought, acid soils, high levels of salt and resistance to diseases.
- Backcross; this method is used to improve some simply inherited, qualitative characteristics in a commercial cultivars or promising elite line. This method is effective in castor for improvement of seed shattering, flower length, and resistance to disease.
- Recurrent selection; this is successive cycle of selection and recombination of selected lines. It is not often used for castor, but it has been used to reduce the height of cultivar Guarani.

8.4 Castor pure line and seed production

Castor is highly cross pollinated crop with the estimates on High Plains of Texas ranging from 70 – 90% [4]. Consequently, self pollinated seed, to generate pure lines, can only be produced by sacking individual inflorescences prior to flower opening. The seed production field must be isolated to obtain pure seed. The isolation requirement is at 300m for foundation seed class and 150m for certified seed class.

9. Castor Varieties

In the early phase, attention was given to ornamental varieties of castor with attractive qualitative characters while in later stage greater emphasis was shifted to varieties for oil production. Ornamental varieties, use in parks and other public places, include;

- Gibsoni, a red-tinged leaves variety with reddish veins and pinkish-green seed pods.
- Carmenicita Pink, a similar variety to Gibsoni with pinkish-red stem.
- Carmencita Bright Red having red stem, dark purplish leaves and red pods.
- Impala, a compact variety grow up to 1.2m with reddish foliage and stem.
- Red Spire is a tall castor with red stem and bronze leaves
- Varieties for oil production: Several research institutions and universities are seriously working to develop castor varieties suitable to agronomic condition of their respective countries. Development of pistillate lines has allowed breeders to successfully use heterosis in castor.

I. Agricultural Science Academy of Zibo in China developed; ZiboCastor No. 2; a middle late castor with high oil content and 3750 – 5399 kg/hm^2 seed yield
II. ZiboCastor No. 3; a spineless , big seeded castor variety
III. ZiboCastor No. 4; a high yielding castor (4500 – 6000 kg/hm^2) with lot of spikes
IV. ZiboCastor No. 5; A middle maturing, thorn less hybrid with 4500 – 6450 kg /hm^2
V. ZiboCastor No. 6; Early maturing hybrid variety, yielding between 4579.5 kg/hm^2 and 6750 kg/hm^2
VI. ZiboCastor No. 8; A middle maturing hybrid with about 4500 to 6000 kg/hm^2

In USA, castor varieties include; Hale, a dwarf (1.2m) castor variety with several racemes, and Brigham, a castor variety with reduced ricin content. In Brazil, BRS Nordestina and BRS Energia were developed for hand harvesting. GCH6 and GCH5 are some of varieties in India while Abaro and Hiruy were developed in Ethiopia. In Nigeria, there are promising lines of castor which are awaiting release at NCRI, Badeggi.

Biotechnology in Castor Breeding

Modern biotechnology offers great promise in reducing ricin content, improving seed quality, enhancing seed oil content and increasing tolerance to stress. The use of molecular markers assisted selection is also of benefit to castor breeding. The use of genetic engineering to knock out or silence the expression of genes related to allergens and ricin could be highly productive.

However, genetic transformation of castor remains challenging because it is recalcitrant to efficient regeneration of stable, transformed plant. Regeneration of plants from callus culture of castor has been problematic, and lacking of protocol for the regeneration has been restricting development of transgenic cultivars (Sujatha et al., 2008). There are only a few reports on successful castor plant transformation and regeneration. Most of the successful plantlet differentiation have been obtained on apical meristems and shoot tip callus (Sujatha et al., 2008). Alam et. al. (2010) described a protocol for in vitro induction of shoots and roots from cotyledonary nodes of castor seedlings.

10. Pests and Diseases Of Castor

10.1 Insect Pests of Castor

Castor is attacked by multitude of insect pests. The damages cause by insects to castor may be greater than eating leaves or sap lost. The piercing of developing inflorescence during feeding by sucking bugs, especially Miridae is sufficient to cause die-back or premature abscission of capsules. Many of the major pests of castor also damage other common tropical crops, and when

castor is planted in the vicinity of these crops castor become more liable to more attacked by the pests [37]. Chemical as well as appropriate cultural practices are used in the control of castor pests. However, the effect of correct planting time in relation to rainfall is more important than crop protection against these pests. The following are some of castor pests in Africa.

Table 1: Some of Castor Pests in Africa

S/N	*Pests*	*Common names*	*Parts of Plant Affected*
1	*Agrolis spp.*	Cutwarm	Seed and Seedling
2	*Brachytrupes spp.*	Mole crickets	Seed and Seedling
3	*Chrotogonus spp.*	Grasshoppers	Seed and Seedling
4	*Protostropus spp.*	Ground weevils	Seed and Seedling
5	*Zonocerus variegates*	Grasshopper	Seed and Seedling
6	*Sphenoptera spp.*	Borer	Stem
7	*Xylutes capensis*	Borer	Stem
8	*Bemesia tabaci*	Jassid	Foliage
9	*Dasychira spp.*	Tussock moth	Foliage
10	*Empoasca spp.*	Jassid	Foliage
11	*Heliothis spp.*	Bollwaoms	Foliage
12	*Spodoptera spp.*	Leafworm	Foliage
13	*Trialeurodes spp.*	Jassid	Foliage
14	*Calidea spp.*	Peach bug	Flower and fruit
15	*Cryptophlebia leucotreta*	False codling moth	Flower and fruit
16	*Eurystylus spp.*	Mirid	Flower and fruit
17	*Helopeltis spp.*	Mirid	Flower and fruit
18	*Ephestia coultella*	Tropical warehouse beetle	Seed
19	*Lasioderma serricorne*	Cigarette beetle	Seed
20	*Tribollium castanewn*	Red flour beetle	Seed

Sources: [27], [22], [8], [6]

10.2 Castor Diseases

Castor plant (*Ricinus communis*) is reported to suffer severe losses due to many diseases caused by fungi and bacteria. There many causal pathogens known to infections in castor. Some of these pathogens are seed-borne. Foliage diseases appear to have little effect on the final yield unless they defoliate the plant to the extent of affecting the growth, or are transmitted to capsules. Capsule diseases cause more economic damage and some area it is a limiting factor for commercial castor. Common diseases of castor are discussed below.

Table 2: Some Common Diseases of Castor

S/N	*Diseases*	*Common names*	*Symptoms*	*Control*
1	*Alternaria ricini*	Leaf spot	Light brown, generally circular spots on the leaves which later turn to angular with age	Treat the seed with Captan or Thiram at 3g/kg seed or spray Mancozeb at 2.5g/lit concentration at interval of days commening from 90days of growth
2	*Cercospora ricinella*	Leaf spot	Light brown, generally circular interveinal spots with margins of concentric rings, the outer broad and dark, later becoming grey with age	-Spray with Bordeaux mixture or other copper fungicides. -Spray with Mancozeb 2.5g/lit or Carbendazim 1g/lit at 10 – 15days interval
3	*Xanthomonas ricinicola*	Bacterial leaf spot	Numerous small, round, water-soaked spots aggregate towards the tip, becoming angular and dark brown to jet black. The spot appears at both side of the leaf	-Burning of plant debris - Seed treatment with 58 – 60 ^{0}C hot water for 10 minutes -Use of resistant varieties
4	*Melampsora ricini*	Rust	Masses of orange colouration underside of leaves	Spray with fine sulphur powder at 20 – 30 kg/ha
5	*Botrytis rivini*	Capsule mould	A dense 'woolly' growth on the flowers and capsules varying in colour from pale to olive-grey. Also affect leaves and stems by infection from racemes.	-Avoid excess irrigation -Use non-spiny variety -Spray Carbendazim 0.05% or Thiophanate 0.05% at 15 days interval -Seed treatment with carbendazim at 3g per kg and spraying with carbendizm 1g/lit 6-8 hours before rain.

Sources: [27], [22], [8], [6]

10.3 Castor Ecology

Castor is a hardy crop which survives in a wide range of ecology. Basically castor grows throughout the warm-temperate and tropical regions, it flourishes under varieties of climate conditions that its range cannot easily be defined. It growns almost anywhere land is available. Castor is basically a long-day plant, but is adaptable with fewer yields to a wide range of photoperiod. However, castor flowers normally on both a short 12 – hour and a long 18 – hour day, but at 9 hours growth and development were severely retarded [37]. Castor grows in all kinds of soils but prefers a well drained moisture retentive soil like sandy loam. It grows well in on a rich soil and tolerates not less than daytime temperatures of 20 [10]. Castor tolerates pH of 4.5 to 8.3 and annual temperature of 7 to 27.8 ^{o}C and annual precipitation of 20 to 429cm.

Although castor can be successfully cultivated in areas of marginal agronomic potential, production is nonetheless sensitive to extreme climatic variations, particularly with regard to rainfall distribution. Cultivated castor requires fertile, well aerated soils with a pH of 6 – 7.3 and rainfall of 600 – 700mm for optimum yield. Insufficient nitrogen results in reduced seed yields. Excessive nitrogen results in extensive and heavy vegetative growth with non-significant increase in yields. The amount of nitrogen requirement depends on the soil organic matter content. Basically castor requires the same amount of nutrients as other low-demand field crops [10].

11. Economic Importance

Castor is an important oilseed crop with great utilitarian value in industry, pharmaceutical and agricultural sectors. The seeds contain between 40% and 60% oil. Its oil is unique among vegetable oils because the oil is the only commercial source of a hydroxylated fatty acid. The presence of hydroxyl groups and double bonds in the ricinoleic acid imparts unique chemical and physical properties on castor oil that makes the oil a vital industrial raw material. In the last couple of years, demand for castor oil has kept increasing in the international market, assured by more than 700 uses, ranging from medicine and cosmetics to biodiesel, plastics and lubricants. The oil has advantages over petroleum base oils, especially at high and low temperatures because of its high boiling and low melting points [23],[20]. Besides reducing greenhouse gases because of its high oil content, it produces relatively high crop yield with relatively low input. In the eastern part of Nigeria, the castor seeds are used to prepare a fermented food condiment called *OGIRI (NCRI, 2013).*

11.1 Castor Oil in Medicine and Cosmetics

Castor oil is one of natural products that fight several ailments. It contains active ingredients that make it take central position in production of several medicinal and cosmetic products [35].

i. **Skin diseases/disorders:** Castor oil is every effective when it comes to treatment of skin problems like sunburn, acne, ringworm, wrinkles and fine Lines dry skin and stretch marks. It also prevents infections like warts, boils, athlete's foot and chronic itching. The oil is good skin moisturizer and disinfectant of wound.
ii. **Hair treatments:** Castor oil is mixed with coconut or almond oil to initiate hair growth, thicken of eyebrows and eyelashes. The oil boosts blood circulation to the follicles, leading to faster hair growth. The oil also has omega-6 essential fatty acids, responsible for healthy hair. The oil is also used for correction of bald patches and hair darkening.
iii. **Other medicinal uses:** Castor oil is a great additive and powerful laxative that serves as remedy for aliments like Multiple Sclerosis, Parkinson's disease, Cerebral Palsy, Pain from Rheumatism, Gastrointestinal Problems, Menstrual Disorders, Migraines, Age Spots, Skin Abrasions and Inflammation.

11.2 Castor in Agriculture

i. **Castor meal and husk for animal feed**: Detoxified castor meal can be used as feed [14]. Castor meal detoxified by boiling could be added up to 100gkg^{-1} in broiler finishing diets without deleterious effects [3]. Castor meal detoxified by autoclaving can replace up to 67% of the soybean meal in sheep rations [24]. The husk is a low value by-product that can be used as roughage for ruminants. A sample castor husks containing a considerable amount of seed fragment (60g kg^{-1}) was evaluated for feeding dairy goat. When hay was completely replaced by castor husks, there was reduction (27%) in milk but increase (28%) in lipid concentration. The husks were not subjected to any detoxification process and no symptom of toxicity was observed [29].
ii. **Castor meal as an organic fertilizer**: The use of castor meal as organic fertilizer is very advantageous because of high N content, fast mineralization, and anti-nematode effects. The mineralization castor meal was evaluated to be 7 times faster than bovine manure and 15 times faster than bagasse of sugarcane. Castor meal has been reported to promote the growth in wheat and castor plants [11], [15]. Castor husks can also be use as organic fertilizer but must be blend with a N-rich organic material to provide a better nutrient balance for plant growth [16], [15].

11.3 Castor Oil in Biodiesel

Biofuels are becoming big policy and big business as countries around the world looking to decrease petroleum dependence, reduce greenhouse gas (GHG) emissions in the transportation sector, and support agricultural interests.

Production of biodiesel from castor oil is technically feasible. The major constraint has been the high price paid for the oil as industrial oil because of high demand by the chemical industries to manufacture very high value products. Biodiesel produced from castor oil has a remarkable advantage regarding lubricity because of its high energy value and positive fuel properties [9], [26], [4].

11.4 Other Industrial Uses of Castor

Castor oil can be used as bio-based polyol in the polyurethane industry. In food industry, castor oil is used in food additives, flavoring, candy, and as mold inhibitor [38]. The oil can also be used to prevent rice, wheat and pulses from rotting. The oil is also important raw material in paints and nylon industries. Castor wax produced by hydrogenation is used in polish, electrical condensers, carbon paper and as a solid lubricant.

11.5 Castor Seed as Food Condiment

The white, large seeds of castor are important sources of food condiment called *Ogiri* in the South-Eastern part of Nigeria. The condiment is believed to improve eye vision. The condiment is prepared by: removing the seed coat, boil the cotyledons for 8 – 10 hours, sieve the cotyledons, leave the sieved cotyledons to stand for 12 – 14 hours then ground the cotyledon to paste as *Ogiri*. The condiment can be stored for several months as the oil content inhibits the growth of microbes. The condiment is a special delicacy in *Igbo* in land in Nigeria. 5 – 7g of the condiment may cost between 0.333 – 0.667 USD [14].

12. Conclusion

Castor varies greatly in its growth and appearance. The stem is round and glabrous, sometimes covered with a waxy bloom which gives red or green stems a bluish appearance on the field. The leaves are large, often dark glossy green with long petioles. The flowers are borne on inflorescence which forms a pyramidal raceme known as spikes or candle. The racemes are borne terminally on main and lateral branches. The fruit is usually a schizocarp; a spiny capsular fruit with three cells each of which splits open at maturity. Castor plant grows naturally over a wide range of geographical regions and similarly can be cultivated under a variety of physical and climatic regimes.

Castor plant is seen as an ideal candidate for agricultural revenue-generating produce which has the potential to become the premier vegetable oil for industries across the country. The high potential yield and unique fatty acid composition allow castor oil to produce economically competitive feedstock needed for production of premium quality biodiesel, short chain aviation fuels, derived fuel lubrication additives and very high value biopolymers.

However, integrated research efforts to boost the global production of castor are critical roles of the scientists. The researchers who are working on castor should cultivate increased international cooperation in development of solutions to the main constrains to castor production, processing and marketing. The research priority should be placed on holistic castor collection and characterizations, and development of technology for improved varieties and completely mechanized castor production.

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