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# Analysis of the Chemical and Physical Properties of Grey Small Sized Castor Seed and Oil (*Ricinus communis* L.)

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## Abstract

The dry seeds of Grey Small Sized (GSS) variety of castor were prepared for analysis by removing the endocarp, sun-drying and milling to flour. The seeds as well as the crude oil obtained were investigated for physical and chemical parameters. The results obtained for the chemical properties of the seeds were: ash (2.9%), crude oil (33.2%), crude fiber (0.5%), crude protein (18.1%), carbohydrate (33.0%) and physical properties: moisture content (12.3%), length (1.32cm), width (0.82cm), thickness (0.56c), slenderness ratio (1.605), bulk density (0.5433g/cm3), and sphericity (0.774 cm3). The chemical properties of the oil were: acid value (2.0mgKOH/g oi), iodine number (84.0), peroxide value (3.4meq/kg oil), saponification value (178.12mgKOH/g oil), unsaponifiable matter (0.6%) and physical properties: viscosity at 25ºC (8.3), specific gravity (0.965l), and refractive index (1.4761). The chemical and physical properties of "GSS" castor oil makes it suitable for various applications in the cosmetics, paints, inks, textile, and pharmaceutical industries, hence, the primary, secondary and tertiary production should be increased as castor is not a major farm produce in Nigerian. Knowledge of the seed's properties will help in designing of processing equipment for castor seed.

**Keywords:** Castor Seed, Castor Oil, Grey Small Size, Physical Properties, Chemical Properties.

## Introduction

Castor plant (*Ricinus communis L.*), from which castor beans and oil is derived, are native to the Ethiopian region of Eastern Africa, and are now grown in the tropical and warm temperate regions all over the world and is becoming wide spread as weed in the South Western United State (Nangbes *et al*., 2013). It grows naturally over a wide range of geographical regions. Castor bean contains approximately 30-35% oil. The crude oil has a distinct yellow colour with unique taste and odour, but can easily be deodorized like any other vegetable oil (Nangbes *et al*., 2013).

The seed from castor bean plant may have received little attention by agriculturists due to its toxicity to human, animals and insects. This is because of ricin, which is a highly toxic storage 7 S lectin, which agglutinates the red blood cells when castor is ingested by either human or animal. Ricin could also be detrimental to workers exposed to castor bean grains by either inhalation or skin contact during industrial activities. Ricin has been used experimentally in medicine to kill cancer cells (Centers for Disease Control and Prevention, 2013).

Castor cake which is the residue from extraction of the castor oil is rich in valuable proteins and fiber and can be detoxified, to be safely used as meal for livestock. Castor cake can also be used as an organic fertilizer due to its high nitrogen and phosphorus (Sousa *et al.*, 2017; Patel *et al.*, 2017). Castor meal detoxified by autoclave can be used to substitute about 67% of soybean meal for sheep (Borja *et al.*, 2017). It can also be detoxified by boiling or fermentation and used as a supplement in broiler finish (Akande *et al.*, 2016), and in Nigeria to make a food condiment called "Ogiri" which is of great benefits to human health (Salihu *et al.*, 2014). Castor oil from castor seed is not toxic, because none of the toxic components is transferred into the oil, but has been a relevant natural remedy for the total well-being of the body (Nangbes *et al.*, 2013). Castor oil in medicine has been used to cure numerous diseases due to its anti-inflammatory properties. It has been used to treat issues like menstrual pain, gastrointestinal infection, athlete's foot, sunburns, and induction of labour pain (Anjani, 2012; Kelly *et al.*, 2013). In the food industry, castor oil is used as a mold inhibitor in food preservation and manufacturing of additives, flavours, and candy (Yeboah *et al.*, 2021).

The major constituent of castor oil includes; ricinol, stearic, dihydroxy stearic, oleic and linoleic, triacylglycerols. Castor oil possesses constant viscosity and remains liquid even at very low temperatures, which makes it a good lubricating oil (Mandal, 2023). The usefulness of castor oil as relevant raw material in the chemical industry, is as a result of ricinolenic acid, a hydroxy monounsaturated fatty acid which is a major constituent of its fatty acid profile. Ricinoleic acid (cis-12-hydroxy-9-octadecenoic acid) with an unusual polarity because of the hydroxyl group position (Parekh *et al.*, 2011) allows for several chemical reactions, such as halogenation, dehydration, alkoxylation, esterification, and sulfation, which confers on castor oil its relevance in several industrial applications such as soap products, lubricants, hydraulic and brake fluids, coatings, plastics, and polishes (Patel *et al.*, 2016). The triacylglycerols and other fatty acids such as palmitic, stearic, and linoleic in castor oil makes it useful in textile industry, the dyes, and inks industry (Mandal, 2023). The oleic acid in castor oil is resistant to oxidation and can be useful in improving the function of antioxidants and anti-polymerization agents (Anjani *et al.*, 2012).

The chemical properties of castor oil include acid value, peroxide value, saponification value, iodine value, and unsaponifiable matter; while that of the seeds are: crude lipid, carbohydrate, crude fiber and ash. The physical properties of castor oil include relative density, viscosity, refractive index, and optical rotation; while the physical properties of seeds are: size and shape, bulk density, weight, sphericity, moisture content and slenderness ratio (Singh, 2022).

Castor seed and its derivatives have found wide application in modern technology with several industrial uses in developed countries. Nigeria over the years has not maximized this crop because of no up to date data on the chemical and physical properties of the seed and oil, which must be known for developing new consumer product of its origin and enhancing its processing and utilization (Onwuka, 2018). There is therefore the need to determine these properties which will serve as information to agriculturists, engineers and industrialists. The aim of this study was to analyze the chemical and physical properties of the seed and oil of the Grey Small Size (GSS) variety of castor plant grown locally in Nigeria, with the view of exposing its industrial and health potentials and obtaining useful information in its handling and processing.

**Statement of the Research Problem**

The properties of castor as studied by several researchers differ with countries, as soil and climatic conditions differ from one country to another, so also various species differ within countries. The properties of Grey Small Size (GSS) variety of castor grown locally in Nigeria has not been evaluated.

Nigeria has not maximized castor plant because of limited information on the chemical and physical properties of the seed and oil which will enhance its useful application and overall utilization.

**Objectives of the Study**

The specific objectives of this study are to:

1. Determine the physical and chemical properties of Grey Small Size (GSS) castor seed.
2. Determine the physical and chemical properties of Grey Small Size (GSS) oil.

## Materials and Methods

**Materials**

The Grey Small Size (GSS) variety of castor seeds were sourced from National Research Institute for Chemical Technology (NARICT) farm, Zaria, Nigeria.

**Plate 1:** Image of Grey Small Size (GSS) Castor Seed

The seeds were cleaned and sorted by hand, removing broken and immature seeds and sun-dried. All the analysis was carried out at the chemical laboratory of the National Research Institutes for Chemical Technology (NARICT), Zaria, Nigeria, using standard methods. All the chemical and physical determinations were done in triplicates, and average values evaluated in each case.

### Chemical Analysis of Grey Small Size (GSS) Castor Seed

Analysis of chemical properties of castor seed; moisture, ash, crude lipid, crude protein and crude fiber were determined using the AOAC method (2005).

The total carbohydrates were determined by difference. The sum of the percentage moisture, ash, crude lipid, crude protein and crude fiber was subtracted from 100 (National Research Council (US), 1989).

The chemical properties of castor oil; iodine value, acid value, peroxide value, saponification value and unsaponifiable matter were determined by IUPAC (1992) method.

### Determination of Physical Properties of Grey Small Size (GSS) Castor Oil

#### Determination of specific gravity (25°C)

The method described by Abdulrahim *et al*., (2000) was used to determine specific gravity. The density bottle was cleaned, dried, cooled in a desiccator and weighed. It was filled with distilled water and maintained at 20°C until the water inside reached 25°C. The outside of the bottle was wiped and weighed. The bottle was emptied of water, dried and filled with oil sample (25°C). The outside was wiped and the bottle with oil weighed.

$$\text{Relative density} = \frac{W_3 - W_1}{W_2 - W_1} \qquad (a)$$

$W_1$ = weight (g) of density bottle

$W_2$ = weight (g) of density bottle + water

$W_3$ = weight (g) of density bottle + oil

#### Determination of Refractive Index (25℃)

Abbe Refractometer was used in this determination of the refractive index of castor oil. Few drops of the sample were transferred into the glass slide of the refractometer. Distilled water at 25°C was circulated round the glass slide to keep its temperature uniform. Through the eyepiece of the refractometer, the dark portion viewed was adjusted to be in line with the intersection of the cross. At no parallax error, the pointer on the score pointed to the refractive index. This was repeated and the mean value noted and recorded as the refractive index.

#### Determination of Viscosity

The method described by Akpan (2006) was used to determine viscosity. A clean, dried viscometer with a flow time above 200 seconds for the fluid to be tested was elected. The sample was filtered through a sintered glass (fine mesh screen) to eliminate dust and other solid material in the liquid sample. The viscosity meter was charged with the sample by investigating the tubes thinner arm into the liquid sample and suction force was drawn up to the upper timing mark of the viscometer, after which the instrument was tuned to its normal vertical position. The viscometer was placed into a holder and inserted to a constant temperature bath set at 25°C and allowed approximately lo minutes for the sample to come to the bath temperature at 25°C. The suction force was then applied to the thinner arm to draw the sample slightly above upper timing mark. The afflux time by timing the flow of the sample as it flows freely from the upper timing mark to the lower timing mark was recorded.

**Determination of Physical Properties of Grey Small Size (GSS) Castor Seed**

**Moisture Content Determination**

The air-oven method described by AOAC (2005) was used to determine moisture content of castor seed based on weight loss as a result of drying the sample to a constant weight in air-oven at specific temperature and time.

**Bulk Density Determination**

Bulk density was determined using the method described by Jones et al., (2000). 250ml capacity measuring cylinder was weighed and filled with 100g of dry flour samples and kept on a wooden surface. It was tapped gently on the laboratory bench several times until there was no noticeable change in the volume. Apparent bulk density was calculated based on weight and volume.

Bulk density (g/cm$^3$) = $\frac{weight\ of\ sample\ (g)}{volume\ of\ sample\ (cm^3)}$ (b)

**Sphericity Determination**

Sphericity was determined by the method described by Oje (1993). Seeds were randomly picked from prepared sample of the two varieties of seed and numbered a to c. Measurements of dimensions on three mutually perpendicular axis viz major, intermediate and minor diameter were done using a pair of vernier caliper with a least count of 0.01mm and the average diameter calculated.

Sphericity S = $\frac{(abc^{1/3})}{a}$ (c)

Where a = major diameter of seed

b = immediate diameter of seed

c = minor diameter of seed (Mohsenin, 1986).

**Measurement of Axial Dimensions**

The axial dimensions of the seeds were done with a pair of vernier calipers with a least count of 0.01mm. These include the length, width, thickness and the slenderness ratio (L/W) of the seeds. (Mohsenin, 1986)

**Statistical Analysis**

The tools for analyses were measures of dispersion, where the samples for the two varieties were replicated three times each for the various properties. After the experiment, the analysis of the data was carried out by drawing out the sample mean, standard deviation and variance. Sample mean is given by:

$\bar{X} = \sum_{i=1}^{n} X_i/n$

(d)

Where n number of replications

$\sum X_i$ = the sum of the observations from X to X

Sample Standard deviation (s) = $\sqrt{\sum_{i=1}^{n}(X-\bar{X})^2/n-1}$ (e)

$$= \sqrt{\sum_{i=1}^{n} X_1^2\ /n-1}$$

Where $\sum_{i=1}^{n}(X-\bar{X})$ stands for the summation of the deviation from the sample mean, which must be equal to zero.

n – 1 = the total number of replication less than 1.

Sample Variance is the square of the standard deviation

$S^2 = (\sqrt{\sum_{i=1}^{n}(X-\bar{X})^2/n-1})^2$ (f)

(Snedecor and Cochran, 1989)

## Results, Discussion & Recommendations

### Results

The results of the analysis carried out on the chemical and physical properties of Grey Small Size (GSS) castor seed and oil are shown in Tables 1 to 4

**Table 1**: Chemical Properties of Grey Small Size (GSS) Castor Seed

| Property | Average value |
|---|---|
| Crude oil | 33.21±0.3380 |
| Ash | 2.91±0.0360 |
| Crude fiber | 2.91±0.0360 |
| Crude protein | 8.111±0.3105 |
| Carbohydrate | 33.02±1.3409 |

**Table 2:** Physical Properties of Grey Small Size (GSS) Castor Seed

| Property | Average value |
|---|---|
| Length (cm) | 1.32±0.125 |
| Width (cm) | 0.82±0.038 |
| Thickness (cm) | 0.56±0.012 |
| Weight (g) | 0.314±0.0308 |
| Slenderness ratio (L/w) | 1.605±0.0102 |
| Sphericity ($cm^3$) | 0.774±0.0369 |
| Bulk density ($g/cm^3$) | 0.5433±0.0051 |
| Moisture content (%) | 12.3±0.4334 |

**Table 3:** Physical Properties of Grey Small Size Castor Oil

| Property | Average value | ASTM* Standard |
|---|---|---|
| Specific Gravity (25°C) | 0.9651±0.0014 | 0.957 – 0.961 |
| Refractive Index (25°C) | 1.4761±0.0283 | 0.476 – 0.478 |
| Relative Viscosity (27°C) | 8.29±0.13295 | - |

*American Society for Testing and Material

**Table 4:** Chemical Properties of Grey Small Size (GSS) Castor Oil

| Property | Average value | ASTM* Standard |
|---|---|---|
| Acid Value (mgKOH/goil) | 2.03±0.2671 | 2 (max) |
| Peroxide Value (meq/kgoil) | 3.40±0.0713 | - |
| Iodine Number | 84.03±0.0836 | 83 – 88 |
| Saponification Value (mgKOH/goil) | 178.12±2.6665 | 176 – 184 |
| Unsaponifiable matter | 0.61±0.0037 | |

*American Society for Testing and Material

**Table 5:** Codex Standard Specifications for Chemical and Physical Characteristics of Crude Vegetable Oil

| | Palm Super olein | Rapeseed oil | Rapeseed oil (low crucic acid) | Rice Brain seed oil | Safflower seed oil | Safflower oil (high oleic acid) | Sesame seed Oil | Soya bean seed oil | Sunflower seed oil | Sunflower seed oil (high oleic acid) | Sunflower (mid oleic Acid) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Relative Density | 0.900-0.925 | 0.910-0.920 | 0.914-0.920 | 0.910-0.929 | 0.922-0.927 | 0.913-0.919 | 0.915-0.924 | 0.919-0.925 | 0.918-0.923 | 0.909-0.915 | 0.914-0.916 |
| X°c/water at 20°c | x=40°c | x=20°c | x=20°c | x=20°c | x=20°c | x=20°c | x=20°c | x=20°c | x=20°c | x=20°c | x=20°c |
| Refractive Index (ND 40°c) | 1.463-1465 | 1.465-1.469 | 1.465-1.467 | 1.460-1.473 | 1.467-1.470 | 1.460-1.464 | 1.465-1.469 | 1.466-1.470 | 1.461-1.468 | 1.467-1.4671 | 1.461-1.471 |
| Saponification Value (mg KOH/g oil) | 180-205 | 168-181 | 182-193 | 180-199 | 186-198 | 186-194 | 186-195 | 189-195 | 188-194 | 182-194 | 190-191 |
| Iodine Value | ≥ 60 | 94-120 | 105-126 | 90-115 | 136-148 | 80-100 | 104-120 | 124-139 | 118-141 | 78-90 | 94-122 |
| Unsaponifiable Matter | ≥ 13 | ≥ 20 | ≥ 20 | ≥ 65 | ≥ 15 | ≥ 10 | ≥ 20 | ≥ 15 | ≥ 15 | ≥ 15 | ≥ 15 |

| | Arachis oil | Babassu oil | Coconut Oil | Cotton Seed Oil | Grape Seed Oil | Maize Oil | Mustard Oil | Palm Oil | Palm Kernel Oil | Palm olein | Palm Stearin |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Relative Density | 0.912-0.920 | 0.914-0.917 | 0.908-0.921 | 0.918-0.926 | 0.920-0.926 | 0.917-0.925 | 0.910-0.921 | 0.891-0.899 | 0.899-0.914 | 0.899-0.920 | 0.881-0.891 |
| X°c/water at 20°c | x=20°c | x=20°c | x=20°c | x=20°c | x=20°c | x=20°c | x=20°c | x=20°c | x=20°c | x=20°c | x=20°c |
| Refractive Index (ND 40°c) | 1.460-1465 | 1.448-1.451 | 1.488-1.450 | 1.458-1.466 | 1.467-1.477 | 1.465-1.468 | 1.461-1.469 | 1.454-1.456 | 1.448-1.452 | 1.458-1.460 | 1.447-1.452 |
| Saponification Value (mg KOH/g oil) | 187-196 | 245-256 | 248-265 | 189-198 | 188-194 | 187-195 | 168-184 | 190-209 | 203-254 | 194-202 | 193-205 |
| Iodine Value | 86-107 | 10-18 | 6.3-10.6 | 100-123 | 128-150 | 103-135 | 92-125 | 55.0-55.0 | 14.1-21.0 | ≥ 56 | ≥48 |
| Unsaponifiable Matter | ≥ 10 | ≥ 12 | ≥ 15 | ≥ 15 | ≥ 20 | ≥ 28 | ≥ 15 | ≥ 12 | ≥ 10 | ≥ 13 | ≥ 9 |

*Codex Standard

**Physical Properties of Grey Small Size (GSS) Castor Seed & Oil**

The axial dimensions; length, width, thickness and weight of the Grey Small Size (GSS) seed were 1.32cm, 0.82cm, 0.56cm and 0.314g respectively. It has sphericity of 0.641cm$^3$ and slender ratio of 1.641and moisture content 12.3%. The Grey Small Size seed of castor has bulk density of 0.543g/cm3 These properties are in line with the report of Haque *et al.*, (2009) of moisture content of castor, 10.1%; slenderness ratio, 1.1; bulk densities 0.8g/cc; weight; 0.2g, length; 1.18cm, width; 0.63cm and thickness; 0.41cm.

The specific gravity of Grey Small Size (GSS) is 0.9651. This compared to Codex Standard values for specific gravity of vegetables oils in Table 5 is relatively high. The high specific gravity makes castor oil a good illuminant, giving a bright and steady flame and burning much longer than any other vegetable oil (Hui, 1996). The refractive index of Grey Small Size (GSS) was 1.4761, which fall within Codex Standard for vegetable oils. The high viscosity of GSS, 8.3 will be preferable in cosmetic like lipstick and as an occlusive agent in skin products by lowering the evaporative loss of water from skin (Singh, 2022). The viscous nature of castor oil ranges from 9.3-10 at 25°C as reported by Naik *et al*., (2018), and makes it relevant for diesel fuel and coating.

The crude oil, ash, crude fiber, crude protein and carbohydrate content of Grey Small Size (GSS) are 33.2%, 2.9%, 0.5%, 18.1% and 33.0% respectively. The peroxide value of oil from Grey Small Size (GSS) is 3.4meq/kg oil, indicating that oil of its origin will keep well, for low peroxide mean high quality oil (Hui, 1996). The acid values of oil from GSS is 2.0 mg KOH/g. This falls within the ASTM standards for edibility of oils, which recommended 2 as the limit for acid value of vegetable oils (Yusuf *et al*., 2015). The iodine number of oil from GSS was 84.0 and saponification value, l78.l2 mg KOH/g. High iodine value means high level of unsaturation and therefore high content of unsaturated fatty acids. Since the iodine number is less than 100, the oil can be regarded as non-drying oil which makes it useful for hydraulic brake fluids and lubricants, and also suitable for soap production (Yeboah et al., 2012).

Saponification value of vegetable oil is an indication of the triglyceride. High saponification value indicates low molecular weight of the triglycerides in the oil and confirms the useful application of the oil for the manufacture of soap and other cosmetics, while low saponification value of oil shows high molecular weight of the triglycerides (Yeboah *et al.*, 2021). The oil from GSS has high saponification value of 178.12 mg KOH/g oil and falls within the average range of saponification value 165.50 to 187mgKOH/g oil in castor oilseed reported by Omari *et al*., (2015). Hence, is a suitable raw material in the soap industries and cosmetic products (Nangbes *et al*., 2013). Saponification value of oil seeds have been found to be affected by planting area. Differences in saponification value of oils from oilseeds grown in different region are found in castor (Omari et al., 2013). The unsaponifiable matter in GSS was 0.61. The chemical properties of oil from the GSS variety of oilseed compare favourably with ASTM standards.

Evaluation of the chemical and physical properties of castor seed and oil carried out in this study observed that the oil from Grey Small Size (GSS) has low peroxide value, which implies that it will give high quality oil. The overall results of analysis shows that the physical and chemical properties of Grey Small Size (GSS) castor oil will confer great potentials and importance in the pharmaceuticals, cosmetics, textile, and chemical industries.

## Conclusion

In this study, the physical and chemical properties of Grey Small Size variety of castor seed and oil were analyzed. The results of chemical analysis revealed that oil from this variety possess immense potential for application in the pharmaceutical, cosmetics, textile and chemical industries such as ink, dyes, polishes, and coatings. Knowledge of the physical properties of the seed is useful for design of processing and handling equipment. This is a dynamic step at marketing and exploring the full potential of castor seed in Nigeria, who is lagging behind in castor oil production and processing.

## Recommendations

Castor seed is not a major farm produce in Nigeria, despite the great industrial and economic importance.

- The primary, secondary and tertiary production of Castor seed should be boosted across the country because of its gross economic benefits.
- Further studies should be carried out on the mineral composition and amino acid profile of the Grey Small Size castor to enhance its utilization as an alternative for animal feed.
- There is also need to determine and evaluate the chemical and physical properties of the seed and oil of the other varieties common in Nigeria, the Big Black Size (BBS), White Big Size (WBS) and the Grey Medium Size (GMS). This will help

agricultural engineers to know which of the variety that will be more profitable and suitable in various tertiary processes applications.

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