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Chemical Composition of *Abrus precatorius* L. Seeds

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Authors' contributions

This work was carried out in collaboration between all authors. Author SC collected the plant samples, prepared and preserved them and analyzed the starch, polyphenol, flavonoid and oil contents. Author KSP designed the investigation and coordinated the analyses. Author EKT conducted the XRF measurements. Author AG collected the thermograms. Authors KSP and PMR wrote the original draft. Author PMR took care of the manuscript revision. All authors read and approved the final manuscript.

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ABSTRACT

Aims: *A. precatorius* seed powder is traditionally used in Ayurveda, Siddha and Unani medicine. The objective of present work is to describe the oil, starch, protein, polyphenol and mineral composition of *A. precatorius* seeds.
Methodology: Legumes from *A. precatorius* were collected, and seeds were manually separated. Dried seeds in powder form were employed for the various analyses: solvent extraction was used

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for elucidation of the oil percentage value; starch content was determined by the enzymatic method; total polyphenol and flavonoid contents were spectrophotometrically analyzed using Folin-Ciocalteu and aluminum chloride as the color developing reagents, respectively; and X-ray fluorescence (XRF) was used for the mineral contents assessment.
Results: The seed kernel consisted of stored oil (3.2%), protein (92.0%) and starch (4.8%). The total polyphenol and flavonoid contents were 24710 and 2520 mg/kg (dw). A remarkably high content of polyphenols was observed in the seed coat and the seed pod. P, S and (mainly) K nutrients were hyper-accumulated in the seed kernel. The seeds showed a glass transition at -21°C, two endothermic peaks at 109°C (dehydration and protein unfolding) and at 209°C, and a calorific value (~406 kcal/100 g dw) that exceeded those of *Pisum sativum* L., *Lens culinaris* Medik., and other common pulses.
Conclusions: The seed kernel from *A. precatorius* was mainly composed of stored protein, with low oil and starch contents. High contents of polyphenols, K, Mg, Ca and Fe were found in the seeds. Heavy metals were below the safety limits established for human consumption.

Keywords: Abrus precatorius seeds; minerals; oil; polyphenols, protein; starch; thermal properties.

1. INTRODUCTION

Plants contain many biological compounds in their bodies [1]. *A. precatorius* L. is a perennial high-climbing, twining woody toxic vine, commonly known as rosary pea, jequirity or Gunja (in Hindi), which can be abundantly found all throughout the plains of India as a weed. The roots, leaves and seeds of this plant of the Fabaceae family have found medicinal uses [2,3], and it has been reported to have antiepileptic, antiviral, antimalarial, antifertility, antidiabetic, neuroprotective, neuromuscular, nephroprotective and immunomodulatory effects, immunostimulatory properties and anti-inflammatory activity [4,5]. Its seeds are considered abortifacient, aphrodisiac, antimicrobial, diuretic and poisonous due to presence of *abrin*, and have been found to be useful in affections of the nervous system and for external use in skin diseases, ulcers and hair affections [3]. Their antinutritional factors (total free phenols, tannins, trypsin inhibitor activity and haemagglutinating activity) have also been investigated [6,7]. The seed proteins are rich in most of the essential amino acids, and are deficient only in cysteine and threonine, when compared to the World Health Organization/Food and Agriculture Organization of the United Nations (WHO/FAO, 2011) requirement pattern.
In this work, the nutritional potential and thermal characteristics of *A. precatorius* seeds are described.

2. MATERIAL AND METHODS

2.1 Chemicals and Reagents

AR-grade Folin-Ciocalteu reagent, aluminum chloride, tannic acid, gallic acid and quercetin were supplied by Sigma-Aldrich, and were used for the analysis of the phenols. AR grade sodium maleate buffer, sodium acetate buffer, potassium hydroxide, amyloglucosidase, pancreatic-α-amylase, and glucoseoxidase–peroxidase were purchased from Megazyme International Ireland Ltd., and were used for the starch analysis.

2.2 Sample Collection

The *A. precatorius* plant was botanically authenticated with the aid of standard monographs [8]. The plant was collected in May 2017 from Pt. Ravishankar Shukla University (21.25°N 81.63°E), Raipur, India. The plants (0.5 kg) and surface soil (0.5 kg) samples were collected in separate polyethylene bags. They were transported to the laboratory and sundried for one week in a glass room. The seeds from the legume were manually separated. The *A. precatorius* fruit parts and soil were further dried in an oven at 50°C overnight. The seed pod, seed coat, seed kernel and soil samples were crushed into fine power and sieved at 0.1 mm mesh size.

2.3 Seeds Drying

The moisture content of the seeds was determined by drying at 105°C in an air oven for 6 h prior to the analysis, and mean values are reported. All characterization results are presented on a dry weight (dw) basis.

2.4 Weight Measurements

The mass of seeds was weighed by using the Mettler Toledo (Columbus, OH, USA) electronic balance (AG245). Seeds were randomly selected for the weighing and their mean mass was reported.

2.5 Thermal Characterization

A DSC 204 F1 Phoenix apparatus (Netzsch, Selb, Germany) was used for the differential scanning calorimetry (DSC) characterization. Data collection was conducted in the 25-300°C range with a constant heating rate of 10°C/min. The analytical parameters were determined using the in-built proprietary software (Proteus, v.7).

2.6 Oil Extraction

5.0 g of the powdered seeds were agitated in *n*-hexane (25 mL) in a centrifuge at 2500 rpm for 1 min, according to the procedure described by Górnaś et al. [9]. The combined supernatant liquids were evaporated in a vacuum rotary evaporator at 40°C until constant weight was obtained. The oil content was expressed in % (w/w) on a seed dry weight (dw) basis.

2.7 Starch and Protein Analyses

The starch content in the seed kernel was determined by the enzymatic method [10]. The protein content was computed 'by difference', i.e., after subtraction of the oil and starch contents [11].

2.8 Caloric Value

The energy content of the seeds was estimated by multiplying the percentages of protein, fat and carbohydrate by the factors proposed by Meiners et al. [11].

2.9 Polyphenol Content

A sample in powder form (100 mg) was dispersed in 5 mL of an acetone and water mixture (70:30, v/v), which was sonicated in an ultra-sonic bath for 20 minutes at 20 °C, according to the procedure reported by Bertaud et al. [12]. The total phenolic content (TPC) of each extract, in tannic acid equivalents, was determined by using the Folin-Ciocalteu reagent [13]. The flavonoid content was determined by the aluminium chloride method as quercetin [14].

2.10 Mineral Characteristics

A Bruker (Billerica, MA, USA) III Tracer SD portable spectrometer equipped with a 4W rhodium anode and Xflash SDD 2028 channels was used for the X-ray fluorescence (XRF) elemental analysis of the samples. The calibration was carried out by using standard brown and white cowpea (*Vigna unguiculata* (L.) Walp.) seeds and standard soil sample (NCS DC 73382 CRM) [15].

2.11 Statistics

Total polyphenol, flavonoid, resistant starch, soluble starch and oil content analytical variables were analyzed only for the seeds, whereas the contents of Cl, P, S, K, Rb, Mg, Ca, Sr, Mn, Fe, Cu and Zn elements were determined both in the soil and in the seeds. All analyses were carried out in triplicate.

3. RESULTS AND DISCUSSION

3.1 Physical Characteristics of the Seeds

A group of six *A. precatorius* seeds were enclosed in the oblong, flat and truncate shaped yellowish colored seed pod (Fig. 1). The seeds were scarlet colored, with a black spot, and featured a globose shape. A 125±3 mg per seed weight was obtained for the samples under study. The seed coat was found to be relatively thick (representing 29±1% of the seed weight), while the kernel fraction accounted for 71±2% of the seed weight. The average water content of the seeds was found to be 3.2±0.1%.

Fig. 1. Image of *Abrus precatorius* L. seeds.

3.2 Thermal Characteristics

The DSC thermogram of the seed kernel (Fig. 2) showed a glass transition at -21°C (onset at -25.6°C) and two endothermic peaks at 109°C and 209°C. The glass transition probably reflects rotational mobility of side chains within seed glasses (β-transition or rotation of hydroxyl groups on sugars), although a melting of the stored proteins cannot be excluded. The main endotherm at 109°C corresponds to dehydration and protein denaturation. The second endotherm, with a peak at 209°C, can be attributed to melting of the carbohydrates and other components [16-18]. The enthalpy of these effects was found to be 174.4 and 36.17 J/g, respectively.

3.3 Caloric Value

The energy content of the seeds was found to be *ca.* 406 kcal/100 g (dw), estimated by multiplying the percentages of protein, fat and carbohydrate by the factors proposed by Meiners et al. [11].

3.4 Oil, Starch, Protein and Polyphenol Contents

The seed reserves consist of oil, starch, protein and other constituents, such as trace elements and bioactive compounds. The oil, starch and protein contents in the seed kernel were found to be 2.2±0.1, 4.8±0.2 and 93.0±1.8%, respectively. The concentrations of the soluble and resistant fractions of starch were 0.60±0.06% and 4.2±0.2%. Thus, *A. precatorius* seeds would feature a lipid content similar to that of fenugreek seeds, and a carbohydrate content similar to that of fava beans. The TPC and flavonoids content (Fla) in the seed kernel were relatively low: 14200 and 1900 mg/kg, respectively. In contrast, the TPC (Fla) concentration in the seed coat, seed pod and leaves were found to be 24710±290 (2520±51), 3082±62 (3560±66) and 10230±21 (8000±155) mg/kg, respectively. These values were higher than those reported by Jain *et al*. [19] for seeds collected in the Mumbai region.

3.5 Mineral Composition

The concentrations of P, S, K, Rb, Mg, Ca, Sr, Mn, Fe, Cu, Zn, Mo and Pb in the kernel of *A. precatorius* seeds were found to be 2302, 1841, 11132, 4.0, 1046, 975, 1.0, 25, 213, 13, 48, 1.0 and 1.0 mg/kg, respectively. The values for P, K, S, Mg and Ca in the seed kernel may be regarded as high, while those of other micronutrients (Cu, Mn, Zn and Fe) were moderate, and those of Rb, Sr, Mo and Pb were low. It is worth noting that the concentration of Mg was higher than that of Ca. The concentrations of Ca, Mn, Fe and Zn were higher than those reported by Pani et al. [20] for seeds from another region in India.

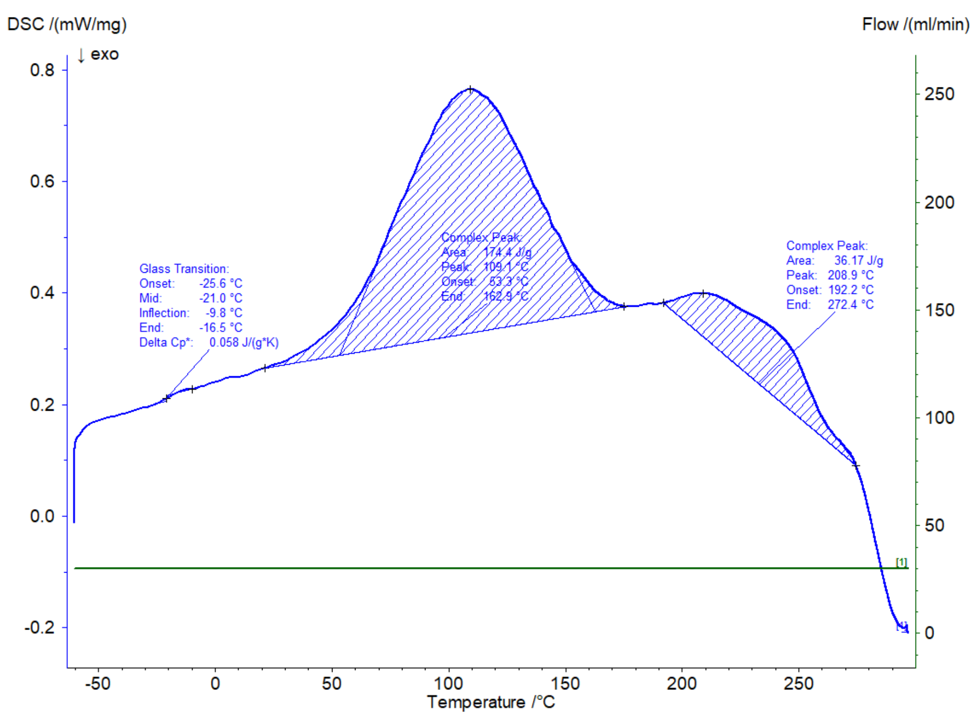

Fig. 2. DSC thermogram of *A. precatorius* seed kernel

3.6 Bioaccumulation Factors

The soil was brown colored with a pH value of 7.7. The mean concentrations of Cl, P, S, K, Rb, Mg, Ca, Sr, Mn, Fe, Cu and Zn were found to be 135, 147, 238, 1370, 7.2, 1480, 6330, 49, 1250, 16700, 48 and 24 mg/kg, respectively. Thus, the soil composition was dominated by K, Mg, Ca, Mn and Fe. Among them, the highest concentration was detected for Fe.

The bioaccumulation factors (BC), which describe the accumulation and enrichment of an element in the seed kernel with respect to the soil, were found to be for 15.7, 7.7 and 8.1 for P, S and K, respectively, indicating an hyperaccumulation of these three nutrients. The BC values for Rb, Mg, Ca, Sr, Mn, Fe, Cu, Zn, Mo and Pb were 0.6, 0.7, 0.2, 0.02, 0.02, 0.01, 0.3, 0.9, 1 and 0.04, respectively.

4. CONCLUSIONS

The results of the present study revealed that the major fraction of *A. precatorius* seed kernel is mostly composed of protein, with low concentrations of oil and starch. P, S and K mineral nutrients were found to be strongly bioaccumulated in the seed, and at least a 1.9-fold molar excess of Mg over Ca was detected in the seed kernel. As regards polyphenol and flavonoid contents, lower concentrations were present in the kernel than in the seed coat and seed pod. The calorific value of *A. precatorius* seeds exceeds the food energy value of other Fabaceae seeds. The deletereous effects of antinutritional substances may be minimised by cooking, since they are heat labile.

CONSENT

It is not applicable.

ETHICS APPROVAL

It is not applicable.

COMPETING INTERESTS

The authors declare no competing interests.

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