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INDIGENOUS AND UNDER-UTILISED OIL SEEDS OF BOTSWANA: PROXIMATE COMPOSITION, PHYTOCHEMICAL SCREENING AND ANTIOXIDANT ACTIVITY

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ABSTRACT: Proximate composition, qualitative screening for phytochemicals (terpenoids, steroids, tannins, oxalates, coumarins, phenols, saponins, and flavonoids) and antioxidant properties in four selected indigenous oilseeds: morama (*Tylosema esculentum*), mongongo (*Schinziophyton rautenenii*), mogose (*Bauhinia petersiana*) and kgengwe (*Citrulus lanatus (Thunb.) Mansf.)* from Botswana was examined. A significant difference ($p \leq 0.05$) was observed in the moisture, fat, protein, ash, carbohydrate, and energy contents. The values ranged from 3.87 – 7.27, 15.99 – 57.70, 12.44 – 33.76, 3.07 – 6.07, and 6.31 – 60.01%, respectively, while the range for the energy content was from 422.35 to 655.29 kcal/100g. Only oxalate was not detected in the qualitative tests performed for eight (8) phytochemical compounds with six (6) solvent extracts. The highest total phenolic content was recorded in morama seeds (1.72 mg GAE/mL), while total flavonoids were better in mogose (0.00813 mg CE/g) and kgengwe (0.00404 mg CE/g). The vitamin C equivalent antioxidant capacity (VCEAC) for mogose, morama, and kgengwe were 2.39, 2.07, and 0.78 mg/100 g, respectively. The study indicated that the oilseeds could potentially be used in the pharmaceutical industry as a source of natural antioxidants. The defatted seeds will have the economic benefit and can be exploited to develop different food products, and dietary supplements to prevent some mineral deficiencies. Further studies on the quality of the oils, the antimicrobial effect of the extracts, mineral and vitamin contents, and isolation, identification, and characterization of the phytochemicals will assist in documenting the complete profile of these oilseeds since they are mostly used as components of traditional medicines.

INTRODUCTION: Botswana is well endowed with underutilized oil-producing plants due to the insufficiency of knowledge and information on their nutritional value, quality of oils extracted from them, and phytochemical profile.

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The plants morama (*Tylosema esculentum*), manketti/ mongongo (*Schinziophyton rautanenii*), mogose (*Bauhinia petersiana*) and kgengwe (*Citrulus lanatus (Thunb.) Mansf.*)) are known to thrive under blazing drought conditions.

For centuries they have provided food, famine relief, and means of livelihood for communities dwelling in the Kalahari Desert and other arid areas of the southern Africa region. The NMR, GC–MS, and ESI-FTICR-MS profiling of fatty acids and triacylglycerols (TAG) revealed that morama seed oil resembled olive oil where C18:1 (47.3%) and

C18:2 (23.4%) fatty acids dominated [1]. Morama showed seven major TAG classes with C54:4 and C54:3 dominating, while manketti had 11 major classes with C54:7, C54:6, and C54:4 dominating; suggesting that morama and manketti (mongongo) seed oils can be developed for food uses. In addition, manketti oil contains unique conjugated fatty acid, α-eleostearic acid, and linoleic, oleic, and linolenic acids [2]. The phytochemicals play a significant role in curing several diseases [3]. Grains of mogose, also known as the "Kalahari white Bauhinia" and "wild coffee bean" is highly drought tolerant and is distributed in Botswana, Zimbabwe, Namibia, and South Africa [4]. The seeds of mogose can be roasted and then pounded, after which a meal with an agreeable taste is prepared. Boiling was reported to be the best method for maintaining the nutritional quality of seeds of *B. petersiana* and reduces the levels of the antinutrients, tannins, phytates, and trypsin inhibitors [5].

In the Kalahari Desert of Botswana, manketti nuts have been used as a staple food source for at least 7000 years [6] and as a source of oils [7]. In Southern Africa, different parts of morama and manketti are used as herbal medicine for anti-angiogenic, anti-inflammatory properties, back pain, cancer, fever, infertility, measles, skin diseases, skin cleanser, skin moisturizer, sleepless nights, and stomachache [8, 9]. These medicinal values might be attributed to alkaloids, anthraquinones, coumarins, flavonoids, phenols, saponins, and triterpenes. According to people residing in Gantsi and Jwaneng areas of Botswana, eating Morama beans makes one live longer, treats diarrhea, boosts the immune system when mixed with devil's claw (*Harpagophytum procumbens*), treats stomach cramps, headaches, prevents hypertension and cleans out infections when consumed mixed with *Acokanthera oppositifolia* tuber.

When consumed with tea, it is believed to improve women's health during post-menstrual periods and enhance milk production in lactating mothers[10]. Mogose is used to treat HIV-related diseases and cough [11], while kgengwe contains considerable nutrients and several bioactive compounds, including L-citrulline and L-arginine, precursors of nitric oxide (NO), polyphenols, and carotenoids, thus are useful potentials for nutraceuticals [12] and suggesting a role in cardiometabolic health [13]. The extracts reduced total plasma cholesterol and low-density lipoprotein without changing triglycerides, high-density lipoprotein, and very-low-density lipoprotein values.

The indigenous and underutilized crops such as morama, manketti, mogose and kgengwe in Botswana contain several bioactive metabolites. However, none of them have gained utilization on industrial scale. It is, thus, imperative to first detect their nutrient values and identify the bioactive compounds (phytochemicals/antioxidants) of these resources and provide recommendations to enhance their contribution to sustainable diets and medicine.

MATERIALS AND METHODS:

Sample Collection: Oilseed samples were collected/harvested from Botswana *viz*. mongongo from Shakawe (18.3673° S, 21.8390° E), morama and mogose from Malwelwe (23.9871° S, 25.2487° E) and kgengwe from Lonetree (20°27'0" S, 24°52'60" E).

Sample Preparation: Mongongo was de-shelled in the traditional way using axe blades. kgengwe seeds were removed from the melons and dried at room temperature. The hard shell of morama was removed by crushing the shell with a rock/stone. Mogose was harvested from dry pods. All the four oilseeds were milled using a mortar and pestle and packed in an airtight Ziploc polyethylene bag. Prepared samples were stored in the refrigerator (4 - 7^{o}C) until further use.

Proximate Composition: The moisture, ash, protein, and fat contents of the samples were analyzed according to Association of Official Analytical Chemists [14], Method Nos: 925.10, 923.03, 920.87, and 920.39, respectively) procedures. Carbohydrate content was calculated as the difference: 100 – (moisture (g) + protein (g) + fat (g) + ash (g)). All analyses were performed in triplicate, and results were expressed in g per 100 g of dry weight (g/100 g dw). The energy content of each oilseed was calculated using the Atwater conversion factor as follows:

$$\text{Energy (kcal/ 100 g)} = 4 \times \text{protein (g)} + 4 \times \text{carbohydrates (g)} + 9 \times \text{fat (g)}$$ [14]

Extraction for Phytochemical Qualitative Tests: Phytochemical extraction was conducted as

described by Ugochukwu *et al.* [15]. The oilseeds were treated with various organic solvents for extraction and qualitative screening tests for phytochemicals.

A 5g ground oilseed sample was dispersed into 50 mL of five solvents (water, methanol, ethanol, acetone, and n-hexane). The solutions were left to stand for two hours at room temperature, then boiled at 60^{o}C for 30 min and the supernatant was filtered through Whatman filter paper No. 1. The filtrate was centrifuged at 2500 revolutions per minute (rpm) for 15 min, and the filtrates were used for phytochemicals screening.

Qualitative test of Phytochemicals: Phytochemical screening (terpenoids, steroids, flavonoids, tannins, coumarins, saponins, oxalates, and phenols) in crude extracts of oilseeds were carried out according to standard procedures.

Terpenoids (Salkowski's test): Each extract (0.5 g) was mixed in 2 mL of chloroform and 3 mL of concentrated sulphuric acid to form a layer. The formation of a reddish-brown coloration at the interface was considered a positive indicator for the presence of terpenoids [16].

Steroids: A steroid test was conducted according to Kumar *et al.* [17]. One mL of the extract was dissolved in 10 mL of chloroform, and an equal volume of concentrated H_2SO_4 was carefully added down the side of the test tube. The presence of steroids was confirmed by changing the upper layer to a red color and the H_2SO_4 layer to yellow color with green fluorescence.

Flavonoids: Two mL of the extract was filtered using a filter paper, then 5 mL dilute ammonia, and 1 mL concentrated H_2SO_4 were added slowly, and the development of a yellow color that disappears on standing was considered as an indicator of the presence of flavonoids [18].

Tannins: To a 2-mL extract, 3 drops of 1% lead acetate were added, and the formation of a yellowish precipitate was taken as an indication of the presence of tannins [19].

Coumarins: To 2 ml of the extract, 3 mL of 10% NaOH was added, and the formation of a yellow color indicated the presence of coumarins [19].

Saponins (Foam test): To 2 ml of the extract, 5 mL of distilled water was added. The mixture was shaken vigorously and observed for the appearance of a stable, persistent froth on warming as preliminary evidence for the presence of saponins [20].

Oxalate: To 3 ml of the extract, a few drops of glacial ethanoic acid was added. A greenish-black coloration was checked to prove the presence of oxalates[15].

Phenols (Ferric Chloride test): Two mL of the extract was treated with 5% aqueous ferric chloride and observed for the formation of deep blue or black color to confirm the presence of phenols [15].

Analysis of Antioxidant Activity, Total Phenols, and Flavonoids: Sample extraction and the determination of DPPH antioxidant scavenging capacity were conducted based on the method described by Dae-Ok Kim *et al.* [21].

Extraction of Sample: Sample (about 0.1g) was weighed and mixed with ethanol-water (50/50 v/v) for their DPPH activities at room temperature in a shaking water bath for 20 minutes. The mixture was then centrifuged (Heraeus biofuge Primo R centrifuge, Model no: 7590) at 4200 rpm for 30 minutes, and the supernatant was transferred into a clean test tube and used for analysis.

L-ascorbic Acid (L-AA) DPPH Radical Scavenging Capacity: L- ascorbic acid standard solution (0.00, 0.20mg, 0.40mg, 0,60mg, 0.80mgand 1.00mg) were weighed into a test tube and dissolved with 10ml ethanol-water (50:50 v/v) for their DPPH scavenging activities and construction of the calibration line. The mixture was then shaken in a shaking water bath for 30 minutes for the reaction to generate the DPPH scavenging by L- ascorbic acid. Ethanol-water (50:50 v/v) (10 mL) was used as a blank.

Determination of DPPH Antioxidant Scavenging Capacity: L-Ascorbic acid series of standard solution (1.5 mL) was pipetted into a clean test tube, and 1.5mL of DPPH was added and incubated in the dark for 30 minutes. Absorbance was measured at 517 nm, and the calibration curve was constructed from the plot of L- ascorbic acid concentrations (x-axis) against the respective

absorbance values of each standard concentration (y-axis). The sample (1.5mL) was also pipetted in a clean test tube, mixed with 1.5 mL DPPH, and incubated in the dark for 30 minutes, and absorbance was measured at 517 nm. The DPPH antioxidant scavenging capacity of the sample was evaluated from the L-AA DPPH antioxidant scavenging capacity calibration line, and results were expressed as L-AA DPPH antioxidant scavenging capacity equivalent.

Determination of Total Phenols: Total phenol contents were determined by the Folin–Ciocalteu method [22]. Diluted extract (40 µL) was added to 1 mL of 1:10 diluted Folin–Ciocalteu reagent. After 4 min, 800 µL of saturated sodium carbonate (75 g/L) was added. After 2 h of incubation at room temperature, the absorbance at 765 nm was measured. Gallic acid (G7384; Sigma-Aldrich) with the concentration range of 0.0, 1.0, 10.0, 25.0, 50.0, 100.0 and 250.0 mg/mL was used for the standard calibration curve (Absorbance = 0.0024 catechin µg - 0.0010, R2 = 0.9989). The results were expressed as gallic acid equivalent (GAE)/g sample on dry weight basis and calculated as mean value ± SD (n = 3).

Determination of Total Flavonoids: Total flavonoid contents were determined by a colorimetric method described in Xu and Chang [23]. A 0.25 mL extract was mixed with 1.25 mL of deionized water and 75 µL of a 5% $NaNO_2$ solution was added. After 6 min, 150 µL of a 10% $AlCl_3.6H_2O$ solution was added to the mixture. The mixture was incubated at room temperature for 5 min, after which 0.5 mL of 1 M NaOH and 2.5 mL of deionized water were added. The mixture was then thoroughly vortexed, and the absorbance of the pink color was measured at 510 nm against the blank. For the calibration curve (+)-Catechin was used with concentrations of 0.0, 10.0, 20.0, 40.0, 60.0, 80.0 and 100.0 mg/L (Absorbance = 0.0037 catechin mg - 0.0008, R2 = 0.9984). Results were expressed as mg (+)-catechin equivalent (CE)/g of extract.

Statistical Analysis: The presence and absence of a specific phytochemical in each solvent were recorded for the qualitative analysis of the phytochemical. The mean of triplicate measurements was analyzed using a one-way analysis of variance (ANOVA). The Duncan multiple range test (DMRT) compared Means with mean square error at 5% probability using statistical software SAS, 2004 version 9. Mean ± standard deviation was used to express the data.

RESULTS AND DISCUSSIONS:

Nutritional Composition of Oilseeds: The oils extracted from seeds are useful because they can be used for cooking or as ingredients to develop other food products. On the other hand, the defatted seed cake will have an immense economic benefit. Cucurbitaceae oilseeds, after being defatted were used to develop food for children, pregnant and lactating mothers, older people and dietary supplements to prevent some mineral deficiencies [24] and biscuits, soups and snacks were developed from groundnut meal. Traditional foods in several African countries do not have variety and are based on staple food (sorghum, maize, cassava), which may offer at large the calories and are limited in the required nutrients. At present, research has focused on oils extracted from oilseeds and little attention is given to the defatted residues. Therefore, a search for nutritious foods of plant origin, specifically from underutilized plants, is essential.

A significant difference ($p \leq 0.05$) was observed in the moisture, fat, protein, ash, carbohydrate, and energy contents of morama, manketti/mongongo, mogose and kgengwe oil seeds collected from different locations in Botswana **Table 1**. Moisture content ranged from 3.87 (mongongo) to 7.27% (kgengwe). The oil content of mongongo was the highest (57.70%), while that of kgengwe the lowest (15.99%) indicating that mongongo is rich in oil, and the value is comparable to the well-known oil-rich seeds. Reports by Zhana Petkova and Ginka Antova [25] show that the fat content of three varieties of melon (*Cucumis melo* L.) from Bulgaria ranged 41.6 to 44.5%, while several melon varieties, the values reported were from 20.5 to 53.5%.

A similar oil content range (41.5% to 58.67%) from mongongo seed was reported by Cheikhyoussef *et al.* [2]. The yellow oil extracted from the nut contains the rare conjugated fatty acid, α-eleostearic acid and linoleic, oleic and linolenic acids. Manketti/ mongongo oil was a component of value-added commodities in the food, health and cosmetics

sectors [2]. Compared to the oil content of mogose seeds (18.35%), a slightly higher oil content for Bauhinia seeds (22.3%) has been reported by Ammousu *et al.* [26]. The morama bean, also known as gemsbok bean, is an excellent source of oil (24-48%) and rich in mono- and di-unsaturated fatty acids without any cholesterol [27]. The 43.63% oil content recorded in this study is, thus, significant, and the bean can be utilized as an important source of oil. The protein content of the seed oils was within the range of 12.44% in kgengwe and 33.76% in morama. Morama is an excellent source of good quality protein containing 29–39% [27,] and the value recorded in this study makes it a candidate to be considered in food product development and animal feed. The fruit pulp of Mongongo, which is popular in the Kalahari Desert in Botswana is highly nutritious as it contains high amounts of carbohydrates, several amino acids, and vitamins like several other indigenous fruits, including *Sclerocarya birrea* and cashew nuts [28]. The protein content of mogose was reported to be 38% [26] and this value is higher than the result obtained in this research which is 18.19%. The difference might be attributed to soil type, climatic and cultivation conditions. Ash contents of the samples ranged between 3.07% (morama) and 6.07% (mogose), which reflects the mineral contents of the oilseeds. Reports indicate that the mesocarp and seed of morama are good sources of essential minerals such as phosphorus, magnesium, potassium, iron, sodium, copper, zinc and calcium [29]. Mogose contained zinc (6 mg/100 g) and iron (3 mg/100 g) [26], while in Mongongo, essential minerals such as phosphorus, magnesium, potassium, sodium, copper, zinc, and calcium were reported [29]. Calcium, potassium, and manganese were reported in different parts of *Citrullus lanatus* seeds [30]. Mongongo and morama have exhibited the highest energy content among the oilseeds, and this can be attributed to the high-fat content of the samples.

TABLE 1: PROXIMATE COMPOSITION MORAMA (*TYLOSEMA ESCULENTUM*), MANKETTI/MONGONGO (*SCHINZIOPHYTON RAUTANENII*), MOGOSE (*BAUHINIA PETERSIANA*) AND KGENGWE (*CITRULUS LANATUS (THUNB.) MANSF*) OIL SEEDS COLLECTED FROM DIFFERENT LOCATIONS IN BOTSWANA

Parameter	Morama	Mongongo	Kgengwe	Mogose
Moisture (%)	5.79 ± 0.06^{b}	3.87 ± 0.02^{c}	7.27 ± 0.06^{a}	6.28 ± 0.03^{a}
Fat (%)	43.63 ± 0.04^{b}	57.70 ± 0.03^{a}	15.99 ± 0.07^{d}	18.35 ± 0.04^{c}
Protein (%)	33.76 ± 0.06^{a}	27.69 ± 0.02^{b}	12.44 ± 0.03^{d}	18.19 ± 0.01^{c}
Ash (%)	3.07 ± 0.02^{a}	4.44 ± 0.03^{b}	4.30 ± 0.01^{b}	6.07 ± 0.02^{c}
Carbohydrates (%)	13.76 ± 0.05^{c}	6.31 ± 0.07^{d}	60.01 ± 0.05^{a}	51.10 ± 0.06^{b}
Energy (kcal/100g)	582.71 ± 0.09^{b}	655.29 ± 0.11^{a}	433.71 ± 0.06^{c}	422.35 ± 0.16^{d}

Means followed by different superscript letters in the same row are significantly different ($p < 0.05$); Data are mean ± SD of triplicate measurements (n=3).

Qualitative Phytochemical Screening: The qualitative test for phytochemicals in morama, manketti/mongongo, mogose, and kgengwe are presented in **Table 2**. The result shows that the oilseeds under study possess most of the screened phytochemicals, with kgengwe testing positive for all the phytochemicals except for oxalates. It was also revealed that the phytochemicals were extracted efficiently in some solvents more than others.

TABLE 2: PHYTOCHEMICAL SCREENING OF MORAMA (*TYLOSEMA ESCULENTUM*), MANKETTI/MONGONGO (*SCHINZIOPHYTON RAUTANENII*), MOGOSE (*BAUHINIA PETERSIANA*) AND KGENGWE (*CITRULUS LANATUS*) OIL SEEDS COLLECTED FROM DIFFERENT LOCATIONS IN BOTSWANA AND EXTRACTED IN DIFFERENT SOLVENTS

		Mongongo (n=3)			
Phytochemicals	**Water**	**Methanol**	**Ethanol**	**Acetone**	**n- hexane**
Terpenoids	-	+	+	+	+
Steroids	+	+	+	+	+
Tannins	-	-	-	+	-
Oxalate	-	-	-	-	-
Coumarins	-	-	-	+	-
Phenols	-	-	+	-	-
Saponins	-	-	-	-	-
Flavonoids	-	-	-	-	-

MORAMA (N=3)

Phytochemicals	Water	Methanol	Ethanol	Acetone	n- hexane
Terpernoids	+	+	+	+	+
Steriods	+	+	+	+	+
Tannins	-	-	-	-	-
Oxalate	-	-	-	-	-
Coumarins	-	-	-	-	-
Phenols	+	-	-	-	-
Saponins	+	+	+	-	-
Flavonoids	-	-	-	+	-

MOGOSE (N=3)

Phytochemicals	Water	Methanol	Ethanol	Acetone	n- hexane
Terpernoids	+	+	+	+	+
Steroids	+	-	-	+	+
Tannins	-	+	-	+	-
Oxalate	-	-	-	-	-
Coumarins	+	+	-	+	-
Phenols	+	+	-	+	-
Saponins	+	+	-	-	-
Flavonoids	-	-	-	-	-

KGENGWE (N=3)

Phytochemicals	Water	Methanol	Ethanol	Acetone	n- hexane
Terpernoids	-	+	+	+	+
Steroids	+	+	+	+	+
Tannins	+	+	+	+	-
Oxalate	-	-	-	-	-
Coumarins	+	+	+	+	+
Phenols	+	+	+	+	-
Saponins	-	+	-	-	+
Flavonoids	-	-	-	+	-

+ = present; - = absent; n = number of samples used in each test.

Several factors are reported to affect the choice of solvent for qualitative phytochemical analysis [31]. These include toxicity of the solvent and potential health hazards, the amount of phytochemicals to be extracted, rate of extraction, and ease of subsequent handling of the extracts.

Detection of bioactive compounds in a specific solvent offers an insight into its polarity and helps in choosing a suitable solvent for its separation. This implies that detecting phytochemicals from a plant material depends on the type of solvent used for extraction [32]. In the present study, the solvents used were water, methanol, ethanol, acetone, and n-hexane.

In manketti/mongongo, terpenoids were detected in all the solvents except in water while steroids were present in all. Acetone was the relevant solvent for extracting tannins and coumarins, and phenols in ethanol. Oxalates, saponins, and flavonoids did not show in any of the solvents. In Southern Africa, various parts of *S. rautanenii* are used as herbal medicine for back pain, cancer, fever, infertility, measles, skin diseases, skin cleanser, skin moisturizer, sleepless nights, sores and stomachache [33] which is attributed to the presence of alkaloids, anthraquinones, coumarins, flavonoids, phenols, saponins and triterpenes that have been identified from the bark and root extracts of the species. In addition to terpenoids, steroids, phenols and saponins, morama contains flavonoids that are beneficial against cardiovascular diseases [34].

In mogose all the phytochemicals except oxalates and flavonoids were detected while in kgengwe only oxalates were missing. According to Kaur *et al* [35], kgengwe seed powder possesses balanced nutrient compositions with strong anti-atherogenic properties, which may be mediated through alterations in the inflammatory pathways.

Total Phenolics, Flavonoids and Antioxidant Activity: The total phenolics and flavonoids contents and the antioxidant activity of morama,

manketti/mongongo, mogose, and mgengwe oilseeds collected from different locations in Botswana are presented in **Table 3**.

A significant difference ($p<0.05$) was observed among the samples in all the parameters measured.

TABLE 3: TOTAL PHENOLS AND FLAVONOIDS CONTENTS AND ANTIOXIDANT ACTIVITY OF MORAMA (*TYLOSEMA ESCULENTUM*), MANKETTI/MONGONGO (*SCHINZIOPHYTON RAUTANENII*), MOGOSE (*BAUHINIA PETERSIANA*) AND KGENGWE ((*CITRULUS LANATUS (THUNB.) MANSF.*) OIL SEEDS COLLECTED FROM DIFFERENT LOCATIONS IN BOTSWANA

Oil seeds	Total phenols content (mg GAE/g)	Total flavonoids (mg CE/gm)	VCEAC (mg/100 g)
Kgengwe	$0.38^{c} \pm 0.05$	$0.00404^{b} \pm 0.00$	$0.78^{c} \pm 0.02$
Mongongo	$0.07^{d} \pm 0.01$	$0.00015^{d} \pm 0.00$	$0.42^{d} \pm 0.03$
Morama	$1.72^{a} \pm 0.05$	$0.00023^{c} \pm 0.00$	$2.07^{b} \pm 0.02$
Mogose	$1.34^{b} \pm 0.04$	$0.00813^{a} \pm 0.00$	$2.39^{a} \pm 0.03$

*Means with different superscripts in the same column are significantly different at $p<0.05$. GAE: gallic acid equivalent; CE: catechin equivalent; VCEAC: vitamin C equivalent antioxidant capacity.

Total phenols and Flavonoid Contents: Total phenols in morama seeds were high (1.72 mg GAE/mL), compared to a report from Namibia [36], which is 0.87 mg GAE/g. The total phenolic compound content of the root and bark of *S. rautanenii* was reported to be 48.6 and 41.4 gallic acid equivalent (GAE) g/mL, respectively [9]. The total flavonoids in mogose and kgengwe were high and indicated their health-promoting effects exhibiting antioxidant and anti-allergic potential [35, 37].

Antioxidant Activity: Antioxidant activity correlates with the highest amount of phenolic and flavonoid contents. The DPPH scavenging activities of plant extracts that contain high levels of phenolic components such as flavonoids, phenolic acids, and phenolic terpenes were reported to be high [37]. Accordingly, mogose and of morama registered higher values followed by kgengwe. The antioxidant behavior of the oilseeds is attributed to their phenolic content. The high antioxidants in the extracted oils from the seeds are the long shelf stabilities of the oil.

CONCLUSION: Phytochemicals screened in morama, manketti/ mongongo, mogose and kgengwe indicated that they are good candidates for the pharmaceutical, food, and cosmetics industries.

The extracts also showed a significant antioxidant activity which can prevent or slow the advancement of oxidative stress-related disorders. Proximate composition analysis revealed that after being defatted, the remains of the oilseeds will potentially be used in the development of different food products and as an animal feed.

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