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# NUTRIENTS, PHENOLICS, FATTY ACIDS AND MINERAL COMPOSITION OF *TELFAIRIA PEDATA* (SIMS) HOOK SEED KERNELS OBTAINED FROM KILIMANJARO, TANZANIA

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**ABSTRACT**

In this study, the nutrients, phenolics, minerals and fatty acids compositions of the seed kernels of *Telfairia pedata* was determined using standard laboratory procedures. The results from Gas Chromatography - Mass Spectrometry (GC-MS) indicated that the studied *T. pedata* was composed of 2,4-bis(1,1-dimethylethyl)phenol (9%), pentadecanol (2%), di(2-propylpentyl)phthalic acid (5.8%), myristic acid (1.5%), palmitic acid (14%), linoleic acid (44%) and others. Quantification of fatty acids showed linoleic acid (500 µg/mL), oleic acid (350 µg/mL), 5Z,8Z,11Z,14Z-eicosatetraenoic acid (403 µg/mL), palmitic acid (410 µg/mL), heneicosanoic acid (462 µg/mL) and others. Proximate analysis indicated moisture (5.06%), total ash (1.22%), crude fat (62%), crude fibre (0.89%), crude protein (23.05%) and total carbohydrate (7.78%). Mineral composition analysis showed the presence of K (320.71 µg/mL), Na (130.98 µg/mL), Mg (6.45 µg/mL), Ca (8.01 µg/mL), Fe (2.46 µg/mL), Zn (0.62 µg/mL), Cu (0.69 µg/mL) and Mn (0.2 µg/mL). These results suggest that the seeds of *T. pedata* could be a good source of supplements to improve cardiovascular health, insulin sensitivity, immunomodulation, anti-inflammation, and antimicrobials. The seeds could also be a source of proteins, fats, and minerals to alleviate malnutrition especially for children under 5 years. Furthermore, since these seeds are rich in oil, they could be used for production of soaps, paints and lubricants.

**Key words:** Kweme, *Telfairia pedata*, Minerals, Protein, Phenolics, Fatty Acids.

## Introduction

Sub-Saharan Africa is faced with nutrient deficiency despite the efforts made within and outside the region (Ecker *et al.,* 2010, Bain *et al.,* 2013). There are nutrient rich resources available in the region, however, maximum utilization of these resources to alleviate nutrients deficiency problems is a challenge (Mbwana *et al.,* 2017). One of the oil seeds that are under-utilized in sub-Saharan Africa region are those from *Telfairia pedata* (Ajayi & Dullou 2015). *T. pedata* seeds, also called 'kweme' in Swahili or 'nkungu' in Sambaa, belong to the genus *Telfairia*, and in the family Cucurbitaceae (Egbekun *et al.,* 1998, Okoli 2007). The plant is native to Tanzania; however, it is also cultivated in Ethiopia, Kenya, Madagascar, Malawi, Mozambique, Rwanda, Mauritus, Zambia, South Africa and Uganda (Schippers 2002, Okoli 2007).

*Telfairia pedata* fruits are usually edible, the nuts/seeds (shown in Figure 1) can be either eaten raw, roasted, or grounded and used as thickeners in various dishes of vegetables and meat (Ajayi & Dullou 2015, Musalima *et al.,* 2019). Due to high fat and protein contents, ground *T. pedata* seeds are locally used by lactating (nursing) mothers to increase milk production (Minzangi *et al.,* 2015). Apart from being used for medicine to relieve rheumatism and stomach troubles, a variety of products such as cosmetics, candles, soaps could be made from the oil extracted from the seed's kernels (Okoli 2007).

Vegetable oils are a dietary source of essential fatty acids, omega-6 and/or omega-3 fatty acids and vitamin E, and are implicated in the prevention of cardiovascular diseases and inflammation (Kumar *et al.,* 2016). Although vegetable oils are important in human nutrition maintenance, it is reported that children are deficient in some essential nutrients that could be obtained from consumption of vegetable oils (Tulchinsky 2010), that are rich in essential fatty acids (EFAs) and phenolics. Most phenolic compounds exhibit antioxidant activities (Kumar *et al.,* 2016).

Isaiah *et al.,* (2021), reported the physico-chemical and antioxidant properties of Kenyan *T. pedata* seeds extract, and Mwakasege *et al.,* (2021a), also reported the nutritional variability of the seeds of *T. pedata* collected from the agro forests of Kilimanjaro Mountain, Arusha and Tanga. This paper, however, gives a detailed analysis of the nutritional, minerals, phenolics and fatty acids compositions of *T. pedata* seed kernels collected from Chekereni, Kilimanjaro, thus, revealing their potential in industrial development and health maintenance.


(a) (b)

Fig. 1: *T. pedata* seeds (a) and shell broken to expose kernel (b).

## Experimentation

*Sample collection, identification and preparation*

Seeds of *T. pedata* were purchased from local farmers in Chekereni, Kilimanjaro region, Tanzania in January 2020. The purchased seeds were then poured in water, to remove unhealthy seeds that floated. Sample of healthy seeds was well preserved in dry plastic containers and transported to the University of Dar es Salaam. Identification was done by Mr. F. M. Mbago, a senior taxonomist of the Herbarium, Department of Botany, University of Dar es Salaam.

The samples were then washed with cold water and dried, followed by the removal of the fibrous shell, and lastly the inner hard shell was split exposing the kernel. Using a blender, the kernels were ground to fine powder (1025 g) and stored in a sealed and labelled plastic container in a refrigerator, ready for analysis (Nielsen 2014).

*Proximate analysis*

The fine powdered samples of *T. pedata* seed kernels were analysed for their proximate composition following methods described by Association of Official Analytical Chemists (AOAC) (1990). To determine moisture content, the sample was dried in the oven at 110 °C until constant weight was obtained (18 h).

Furnace Incineration method as described by AOAC (1990) was applied to determine total ash. The sample (5 g) was roasted in a furnace at 550 °C until constant weight was established (12 h). The selected method utilises heat to vaporise water and volatiles, and to burn organics to $CO_2$ in the presence of air ($O_2$). The Kjeldahl method was adopted to determine the amount of nitrogen, from which, the crude protein content was then calculated.

*Elemental analysis*

The powdered sample was oven dried at about 100 °C until a constant weight was obtained, then cooled. After cooling, 5 g of the sample was placed in a crucible and dry ashed in a furnace at 400 °C for about 3 hrs. The obtained ash was cooled and subjected to digestion using 25 mL of a mixture (2:1) of acids (6M Perchloric acid, and nitric acid), and the mixture heated on a hot plate (in a fume hood) until dense white fumes appeared. The mixture was then left to cool and filtered using Whatmann filter papers, then, 10 mL of the digest was transferred into a 250 mL flask and diluted to the mark using distilled water. The samples were subjected to Flame Atomic Absorption Spectrophotometry (FAAS) analysis using a Thermo Fisher Scientific model iCE 3000 v1.3 (Saeed *et al.,* 2011). The concentration of metals in the sample were determined before and after spiking, and the percentage recoveries established using the equation below.

$$\% \text{ Recoveries} = \frac{[\text{Spiked}] - [\text{Unspiked}]}{[\text{added}]} \times 100\%$$

These experiments were replicated and recoveries at 95-110% with standard deviation of <5% were considered suitable.

*Phenolics and fatty acids analyses*

*GC MS analysis of the samples*

American Oil Chemists' Society (AOCS) method was adopted for fatty acid methyl esters (FAME) analysis (AOCS 1993). The Gas Chromatography-Mass Spectrometry (GC-MS), a Shimadzu instrument (GCMS-QP 2010 Ultra), operated in Electron Ionization (EI) mode at 70ev was used for these investigations. A Restek-5MS column (30 m × 0.25 mm × 0.25 μm) was used and the oven temperature program was 45 $^{o}$C to 260 $^{o}$C, and held for four minutes. The temperature was increased to 260 $^{o}$C for 12 minutes (hold time) at the rate of 7 $^{o}$C per minute. The injection temperature was at 250 $^{o}$C under a split injection mode. The flow rate of the carrier gas (Helium) was 1.21 mL min$^{-1}$. The ion source temperature and interface temperature in MS were 230 $^{o}$C and 300 $^{o}$C, respectively.

The identification of each fatty acid in the sample was done by comparing the retention time observed in the sample with that of the corresponding standard (Sigma Aldrich, Milan, Italy).

Quantification of each fatty acid in the sample was done using Peak Integration method with an ion allowance of 20%. Target ion and other five quantification ions were used on quantitative analysis.

## Results

*Proximate composition*

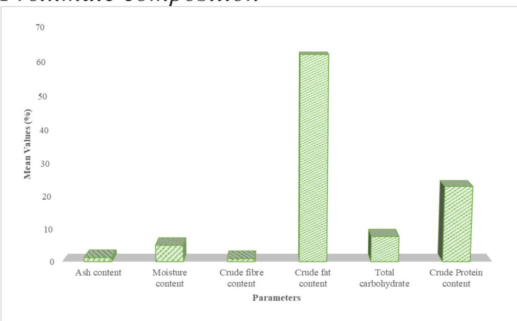


Fig. 2: Nutritional value of *T. pedata* seeds expressed as percentage of mean values.

As shown in Figure 2, *T. pedata* was found to contain crude fat (62.0%), total ash (1.22%), moisture (5.06%), crude fibre (0.89%), total carbohydrate (7.78%), and crude protein (23.05%).

*Mineral composition*

Results for minerals compositions of *T. pedata* seeds as analysed by FAAS are presented as mean ± SD in Table 1.

**TABLE 1**

*Mineral composition of T. pedata seeds.*

| S/N | Type of Mineral | Mean Amount (µg/mL) ± SD |
|---|---|---|
| 1. | Potassium (K) | 320.71 ± 0.01 |
| 2. | Sodium (Na) | 130.98± 0.02 |
| 3. | Calcium (Ca) | 8.01 ± 0.02 |
| 4. | Iron (Fe) | 2.46 ± 0.01 |
| 5. | Zinc (Zn) | 0.62 ± 0.02 |
| 6. | Copper (Cu) | 0.69 ±0.02 |
| 7. | Magnesium (Mg) | 6.45 ± 0.02 |
| 8. | Manganese (Mn) | 0.2 ± 0.02 |

*Fatty Acids and Phenolics in T. pedata*

The qualitative results of fatty acids, phenolics and other compounds in *T. pedata* seeds extract are indicated in Table 2. Figure 3 shows the GC – MS spectrum of compounds in the *T. pedata* seed kernel extract and in Figure 4, structures of some of the compounds depected in the GC-MS spectrum of the *T. pedata* extract. Results in Table 4 indicate concentrations of the fatty acids.

**TABLE 2**

*Qualitative analysis of T. pedata seeds oil*

| Compound Name | % Composition ± SD |
|---|---|
| 2-ethyl-1-butylcyclobutane | 0.098 ± 0.05 |
| *Trans* 1,2-bis(1-methylethenyl) cyclobutane | 0.110 ± 0.07 |
| 1-Tetradecene | 0.298 ± 0.04 |
| 2,4-bis(1,1-dimethylethyl)phenol | 9.013 ± 0.90 |
| *n*-Pentadecanol | 2.352 ± 0.09 |
| Myristic acid | 1.514 ± 0.08 |
| 1-Nonadecanol | 3.441 ± 0.12 |
| Palmitoleic acid | 0.662 ± 0.02 |
| Palmitic acid | 14.036 ± 0.11 |
| Linoleic acid | 44.505 ± 0.14 |
| Nonadecanoic acid | 14.076 ± 0.13 |
| 1-Tetracosanol | 3.030 ± 0.02 |
| 18-methylnonadecanoic acid | 0.702 ± 0.01 |
| Di(2-propylpentyl)phthalic acid | 5.818 ± 0.05 |
| 1-Heptacosanol | 0.843 ± 0.01 |
| | 100.000 |

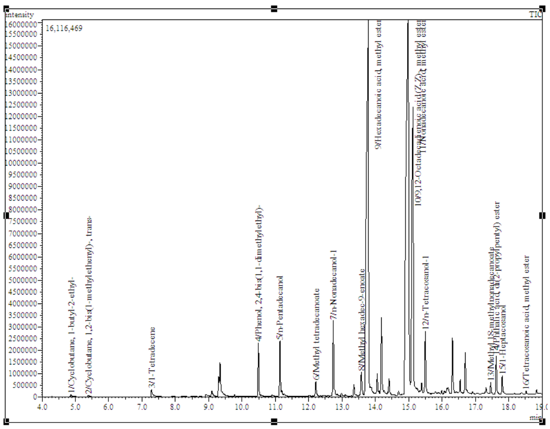

Fig. 3: A GC-MS spectrum showing compounds in *T. pedata* extract

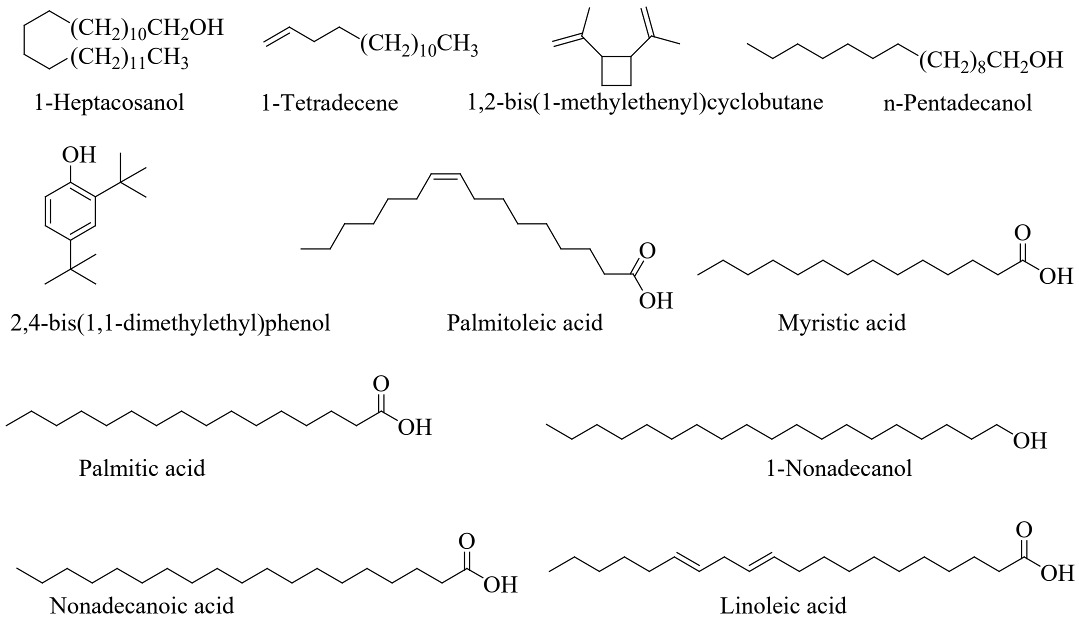


Fig. 4: Structures of some of the phenolics, fatty acids and other compounds detected in *T. pedata* seed kernel extract

**TABLE 3**

*Types of fatty acids present in T. pedata seed kernels*

| Fatty acids | Conc. (μg/mL) ± SD |
|---|---|
| Lauric acid | 103.25 ± 0.10 |
| Pentadecanoic acid | 138.09 ± 0.11 |
| Palmitic acid | 410.59 ± 0.06 |
| Palmitelaidic acid | 122.96 ± 0.02 |
| Linoleic acid | 500.40 ± 0.07 |
| Oleic acid | 350.10 ± 0.04 |
| Cis-10-Heptadecenoic acid | 103.16 ± 0.07 |
| Stearic acid | 138.09 ± 0.09 |
| Heneicosanoic acid | 462.12 ± 0.03 |
| 5Z,8Z,11Z,14Z-Eicosatetraenoic acid | 403.01 ± 0.05 |
| 11-Eicosenoic acid | 106.06 ± 0.02 |
| Docosanoic acid | 139.01 ± 0.02 |
| 18-methylnonadecanoic acid | 124.33 ± 0.03 |
| 20-methyl-heneicosanoic acid | 100.71 ± 0.02 |
| Tetracosanoic acid | 105.94 ± 0.06 |

## Discussion

Proximate analysis of *T. pedata* seed kernels have shown it to be a good source of oil (62 g/100 g), as compared to soy bean oil (20.70 g/100 g), (Szpunar-Krok &Wondołowska-Grabowska, 2022), locust bean (20.20 g/100 g) (Lasisi *et al*., 2023) and cotton seed (20 g/100 g) (Bhattacharya, 2023). The observed amount of crude protein (23.05%) agrees with its local use as the main ingredient in pregnant and lactating mothers' diets. This is because these two categories of people require large proportion of protein intake as recommended by WHO (2010). That is, macronutrient composition of 20% protein, 40% fat, and 40% carbohydrates has been recommended for pregnant women (Kominiarek & Rajan, 2016), and seed kernels of *T. pedata* is found to contain 23.05% crude protein. In addition, the observed crude protein content was comparable to those reported for other oil seeds like cashew nuts, cotton seed, sesame, and peanuts.

Canadian Grain Commission (2022) described moisture content of up to 18% being recommended for storage of oil seeds for up to 40 days, therefore, *T. pedata* seed kernels have shown moisture content of 5.06%, commendable for storage without microbial attack for longer period of time. The expressed moisture content in *T. pedata* is lower than that of *Chrysophyllum cainito* seed (22%) (Okpako *et al.,* 2017) and higher than that of *Jatropha curcas* seeds (4%) (Magu *et al.,* 2018).

Taking adequate dietary fibre ensures reduced risk of cancer and cardiovascular disease, also healthy weight maintenance, and gastrointestinal health maintenance (that is treating and preventing constipation) (Madhu *et al*., 2017). Therefore, since amount of fibre content observed was 0.89%, then, consumption of *T. pedata* seed kernels would require another source of fibre for the maintenance of gastrointestinal health.

For overall health maintenance, maintaining adequate potassium and sodium intake is important. Potassium and sodium help to regulate fluid balance, muscle contractions and nerve signals. Moreover, a high potassium and sodium diet helps to reduce blood pressure and water retention, prevents kidney stones and stroke, and regulation of acid-base balance (Aaron & Sanders 2013). However, consumption of sodium rich diet has been associated with arterial hypertension, and increased risk of cardiovascular disease (Binia *et al*., 2015). Therefore, the World Health Organisation (WHO) recommended a dietary intake of less than 2000 mg of sodium and more than 3510 mg of potassium per day, this results into a ≤ 1.0 Na-to-K ratio, that is scientifically proven to be optimal for cardiovascular health (WHO 2012; Binia *et al*., 2015; Iwahori *et al*., 2017; Bailey *et al*., 2015). The detected levels of sodium (130.98 µg/mL) and potassium (320.71 µg/mL), gives a ratio of ≤ 1.0 Na-to-K ratio, which was recommended by WHO. Therefore, the detected levels of K and Na suggest that *T. pedata* seeds could be a good source of these mineral elements. These values are higher compared to those reported for *J. curcas*, (79.89 ppm and 54.03 ppm for K and Na respectively) (Magu *et al.,* 2018). On the other hand, leaves of *T. occidentalis* as reported by Idris S, (2011) are a superior souce of potassium as compared to the seeds of the plant and seeds of *T. pedata*.

The levels of calcium observed suggests that *T. pedata* seed kernels might not be a good source of calcium. Calcium is not only a major component that sustains strong bones, but it also plays part in muscle contraction and relaxation, synaptic transmissions, blood clotting and even in the absorption of vitamin B12 (Emebu & Anyika 2011; Sunday & Magu 2017). The levels of iron (2.46 µg/mL) were lower than that reported for *J. curcas* (112.46 ppm) (Magu *et al.,* 2018). However, the detected level is below the recommended dietary intake for males and females with ≥ 50 years (8 mg/day), adolescents require high amounts of iron ranging from 18 -24 mg/day (Stoffel *et al*., 2020). Iron has been reported to be an essential trace element, playing biochemical roles in the body, including oxygen-binding in haemoglobin for transport, storage and use (Highina *et al.,* 2012; Idowu *et al.,* 2012). Furthermore, scientific studies have indicated that iron containing proteins such as haemoglobin are involved in transferring electrons in the body (Linus Pauling Institute

2016). Since the amount of iron detected were below the recommended amounts, another source of dietary iron is recommended when consuming *T. pedata* seed kernels.

*T. pedata* seeds contain high oil content, however, the composition of fatty acids and phenolics determine the quality of oil (Izquierdo *et al.,* 2002). It is observed that, this fat contains Poly Unsaturated Fatty Acids (PUFAs) and Mono Unsaturated Fatty Acids (MUFAs) which are highly important for human health maintenance and improvement (Borges *et al.,* 2007). Linoleic acid in *T. pedata* is present in high amount, this is an essential PUFA, and among other health benefits, it has been reported to reduce cholesterol levels in the blood and therefore an essential ingredient in maintaining cardiovascular health. It has been recommended that consumption of linolenic acid and linoleic acid at a ratio of 1:2 would result in reduced rates of cardiovascular diseases and inflammation (Gibson *et al.,* 2011; Simopoulos 2011; Salter 2013; Abedi & Sahari 2014).

It is reported that fatty acids of both omega -6 and -3 nature are essential to human body, however, fatty acids such as linoleic acid (omega-6) and alpha-linolenic acid (omega -3) are prone to oxidative deterioration on high heat applications, indicating instability of the double bond in the structure of the respective molecules. The double bond reacts readily with oxygen (singlet) forming oxidative by-products like free radicals, hydroperoxides, and aldehydes which have detrimental health effects. Due to this observation, a study by Mwakasege *et al.,* (2021b), recommends eating *T. pedata* seed kernels raw, or cooked under low heat, thus, maintaining their composition and goodness.

Myristic acid is a saturated long chain fatty acid, with IUPAC name tetradecanoic acid, molecular formula: $CH_3(CH_2)_{12}COOH$, has been detected in oils of cardamon, coconut, palm kernel, and in butterfat, and bovine milk. Studies have indicated that myristic acid can cause proliferation and differentiation promotion of neural stem cells *in vitro*, and also the acid plays a key role in aging-related disorders, that is, the decline of myristic acid causes aging (Shang *et al*., 2022). The detection of myristic acid in *T. pedata* seed kernels should not be alarming since its consumption has a positive impact on aging control. Furthermore, this fatty acid has been reported to be involved in both, mechanisms that control aging, and post-translational protein changes (Legrand & Rioux, 2015; Ruiz-Núñez *et al.,* 2016). It is furthermore reported that consumption of this compound improves levels of long-chain omega-3 fatty acids in plasma, therefore improving cardiovascular health (Dabadie *et al.,* 2005; 2008). Other reported benefits of consuming myristic acid include increased high-density lipoprotein cholesterol and decreased triacylglycerides levels and immunomodulatory functions (Hubbard *et al.,* 1996).

Although it has been shown that eicosapentaenoic acid could be synthesized from linolenic acid, but the challenge remains to be the low efficiency of the enzymes, therefore, these fatty acids are to be supplied via dietary intake. Studies indicated that populations whose diet consists of high levels of fish, showed lower incidences of cardiovascular disease and rheumatoid arthritis. These results have been linked to consumption of high levels of eicosapentaenoic acids that are abundant in fish (Bailes & Mills. 2010; Lieberman, *et al*., 2010). Therefore, the detection of eicosapolyenoic acids, like 5Z,8Z,11Z,14Z-eicosatetraenoic and 11-eicosenoic acids in seed kernels of *T. pedata* indicates the potentiality of the seeds for cardiovascular control.

2,4-bis(1,1-dimethylethyl)phenol is another metabolite that has been detected in *T. pedata* seed kernels. This compound has been reported to possess antimicrobial, and antioxidant activities among others. The expressed antioxidant activity was reported to be due to its ability to inhibit production of reactive oxygen species (ROS) (Romero-Correa *et al.,* 2014). Therefore, *T. pedata* seed kernels could be a good source of antioxidants, and antimicrobial agents.

Pentadecanol, a fatty alcohol possessing potent anti-acne activities, and effective against *Mycobacterium bovis* and *M. tuberculosis* bacteria. The compound act against the bacteria by destroying the cell membranes, therefore, causing cell lysis. Computational studies on pentadecanol compound, revealed its potency against mycobacteria, and therefore, named as a reference in the development of mycobactericidal agents in the future (Syahputra *et al.,* 2018). Therefore, the detection of this compound in *T. pedata* extract suggested that the extract from *T. pedata* seed kernels could be used as bactericidal agent.

The industrial application of *T. pedata* seed kernels is observed in the detection of Di(2-propylpentyl)phthalic acid, that has been reported to be best for production of consumer products such as cosmetics, food packaging, building materials, medical supplies, home furnishings, among others (Chi *et al.,* 2017; Fan *et al.,* 2017; He *et al.,* 2019).

Another industrial application of *T. pedata* seed kernels is observed in the high amount of oil extracted, indicating the kernels to be rich oil source, and therefore, more scientific studies need to be conducted to ascertain the use of these kernels for paints and soap production, and nutritional supplements production.

A scientific study on *T. pedata* by Isaiah *et al*., 2021, reported 9 fatty acids, (namely; myristic acid, palmitoleic acid, palmitic acid, margaric acid, linoleic acid, stearic acid, 10,13-octadecadienoic acid, 18-methylnonadecanoic acid, and behenic acid), while this study reports 15 fatty acids. However, comparable levels of linoleic acid were observed in both studies.

It is worth mentioning that traditionally, the Pare people (from Kilimanjaro) and people of northern Tanzania, prepare lactating mother's dish with *T. pedata* seed kernels as a 'must' ingredient. It is believed to bring healing especially immediately after giving birth, and increase milk production (Shayo *et al*., 2022). The results reported herein, indicated the seed kernel to contain among others high content of crude protein, minerals such as potassium, MUFA and PUFA that are known to improve cardiovascular health, thus, are highly needed by expectant and lactating mothers. These results, therefore, agree well with the indicated traditional use.

## Conclusions

The present investigation on proximate, elemental, phenolics and fatty acids compositions of *T. pedata* seeds revealed that *T. pedata seeds* have minerals, nutrients, phenols and fatty acids sufficient for health maintenance. The observed data, has therefore, indicated that the seeds are a good source of protein, fat, K, Na, phenolics, linoleic, oleic and palmitic. From the nutritional point of view, *T. pedata* seeds has demonstrated high nutritional values, therefore, families could secure their nutrition by consuming these seeds that are easily available and cheap. Furthermore, this oil could be used for production of detergents, soaps, paints and lubricants. From the elemental analysis, the seeds possess great potential for human nutrition and health maintenance, therefore, it is recommended that further studies be conducted to ascertain how this seed and its extract could be made useful in the production of dietary supplements, livestock feeds, and biodiesel production.

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