# Quality and Compositional Studies of Some Edible Leguminosae Seed Oils in Botswana

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**ABSTRACT:** Seed oils were extracted with *n*-hexane from three edible Leguminosae seeds: *Tylosema esculentum, Xanthocercis zambesiaca,* and *Bauhinia petersiana,* giving yields of 48.2, 17.6, and 20.8% (w/w), respectively. Some physical and chemical parameters were determined to ascertain the general characteristics of the oils. The saponification and iodine values indicated that all three oil samples could be classified among the olive group of oils. This inference was supported by the results of the detailed fatty acid composition of the oils as determined by capillary gas chromatography. The ratio of total unsaturated to total saturated fatty acids in all three oil samples was approximately 70:30, with either oleic or linoleic acid being the dominant fatty acid. These results were in agreement with a proton nuclear magnetic resonance analysis of the fatty acid classes in the seed oils. Thus, the analysis served to justify the use of the three Leguminosae seed oils in food preparations. The work has further indicated that, with their attractive properties, the seed oils from *T. esculentum, X. zambesiaca,* and *B. petersiana* are good candidates for further studies to evaluate their future commercial prospects in the Southern African region.
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**KEY WORDS:** Bauhinia petersiana, capillary GC, fatty acid composition, physical and chemical parameters, proton NMR, *Tylosema esculentum, Xanthocercis zambesiaca.*

A variety of seeds feature quite prominently in the diet of rural communities in many developing countries. Such edible seeds provide essential nutrients, such as proteins, carbohydrates, and lipids. In addition to the use of seeds as a food source, rural communities have also over many generations extracted oils from some of these edible seeds by simple methods, such as grinding and pressing the mash. The potential for such locally produced oils has often been neglected by the formal economic systems of many developing countries because of the ready availability of commercial vegetable oils from the industrialized countries. There is thus little or no scientific information about such vegetable oil products from rural communities. Yet, rural communities have for generations used such oils for food, as components of medicinal applications, and in cosmetic formulations.

This paper discusses some general properties and the fatty acid compositions of seed oils from *Xanthocercis zambesiaca* (moshatu), *Bauhinia petersiana* (motsantsha; English name, wild coffee), and *Tylosema esculentum* (morama), all of which belong to the family Leguminosae. All three species occur in Botswana and other parts of Southern Africa. The seeds of *T. esculentum* have received some attention because of their socio-economic importance to the communities that live in their growing areas. The seeds form a staple diet for the inhabitants of the Kalahari and adjoining districts in Botswana. The seed oil is extracted and used for cooking and for making butter. Yeboah, one of the authors of this article, has reported on some general characteristics of morama seed oil (presentation at the African Biosciences Network International Workshop, University of Malawi, 1988).

Similarly, the seeds of *X. zambesiaca* and *B. petersiana* serve as food sources, and their oils are extracted for local use in the growing areas. However, the general properties and the detailed fatty acid compositions of these three Leguminosae seed oils have not yet been reported.

## EXPERIMENTAL PROCEDURES

*Materials.* Morama beans, *T. esculentum,* were supplied by Thusano Lefatsheng Organization, Gaborne, Botswana. Montantsha (wild coffee) beans, *B. petersiana,* were supplied by Veld Products Research, Gaborne, Botswana. Moshatu seeds, *X. zambesiaca,* were purchased from the Botswana Forestry Association, Gaborne, Botswana.

*Extraction.* The outer covers of the dry seeds were removed, the kernels were macerated in a Waring blender, and the powder was extracted with *n*-hexane in a Soxhlet apparatus.

*General properties.* The physical and chemical properties of the oil samples were determined by standard methods of the International Union of Pure and Applied Chemistry (1). All experiments were conducted in triplicate.

*Fatty acid composition.* The oil samples were transesterified by refluxing in dry methanol with ethanoyl chloride to produce the fatty acid methyl esters (2), and these were used for chromatographic analysis.

*Instrumentantion and separation conditions.* Fatty acid compositions were determined with a Varian 3500 GC with on-column injection and flame-ionization detection (Palo Alto, CA), and a DB-Wax [30 m × 0.25 mm (J&W, Folsom, CA)] capillary column. The carrier gas was helium at a flow rate of 2.3 mL/min. The oven temperature was programmed, starting

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**TABLE 1**
**Physicochemical Properties of *Tylosema esculentum, Xanthocercis zambesiaca,* and *Bauhinia petersiana* Seed Oils**

| Physical and chemical properties | *T. esculentum* | *X. zambesiaca* | *B. petersiana* |
|---|---|---|---|
| % Yield (w/w) | 48.2 | 17.6 | 20.8 |
| Refractive index (30°C) | 1.465 | 1.468 | 1.449 |
| Density | 0.903 | 0.957 | 0.867 |
| Acid value (mg KOH/g) | 2.96 | 2.5 | 1.9 |
| Saponification value (mg KOH/g) | 174 ± 2 | 183 ± 2 | 178 ± 2 |
| Iodine value (Wijs) | 95 ± 3 | 94 ± 3 | 98 ± 3 |
| Peroxide value (meq/kg) | 20.3 | 11.3 | 10.6 |
| Unsaponifiable matter % (w/w) | 0.09 | 0.03 | 0.06 |

at 130°C for 2 min, increasing to 150°C at 30°C/min, and holding for 10 min. Injector and detector temperatures were held at 130 and 250°C, respectively. Reference compounds were either standard mixtures GLE-68 (Nu-Chek-Prep, Elysian, MN) or Memixes (Larodan Fine Chemicals, Malmo, Sweden).

*Nuclear magnetic resonance (NMR) analysis.* Proton NMR spectra were acquired for the neat oils from *T. esculentum* and *X. zambesiaca* at 500 MHz in a Bruker DMX-500 spectrometer (Bruker Analytik GmbH, Karlsruhe, Germany).

## RESULTS AND DISCUSSION

The data collected from the study of the physical and chemical properties of the test samples (Table 1) reveal a striking similarity among the three Leguminosae seed oils. The range of saponification values indicates the absence of lauric oils, while the iodine values (IV) indicate a fair amount of unsaturation in all three seed oils. Indeed, IV of the three test samples fall within the recommended Codex range of IV for the olive group of oils (3).

The peroxide value (PV) of 20.3 meq/kg for morama oil, *T. esculentum,* is rather high but not much higher than the Codex recommended PV for virgin olive oil (20 meq/kg) (3). Thus, as with other seed oils, further processing, which will adjust all quality parameters including the antioxidant level, will improve the shelf-life of morama oil.

The yield of oil from the seeds of morama (48.2% w/w) and the high protein content of the seed (32.4% w/w of kernel) (4) explain the enormous socio-economic value of the morama plant in its growing communities. The root tuber of the morama plant, *T. esculentum,* provides a carbohydrate meal, while the seeds provide lipids and proteins to the inhabitants of the Kalahari region in Botswana. The oil yield from the morama seeds, 48.2%, compares favorably with such commercial vegetable oils as groundnut (45–55%), sunflower (22–36%), and rapeseed (22–49%) (5), and it is thus an indicator of a potential source of commercial vegetable oil.

While the oil yields from the seeds of *X. zambesiaca* and *B. petersiana* are not as high as that of *T. esculentum,* they nevertheless compare quite favorably with the oil yield from soybean (12–30%) (5). These seeds similarly provide nourishment to the inhabitants in their growing areas, and their oils are extracted for a variety of local uses.

The detailed gas chromatographic (GC) analyses of the three oil samples support the earlier inference drawn on their general properties from their physicochemical parameters. Table 2 shows that there are no detectable amounts of lauric acid in the three samples, and the bulk of the oils is made up of $C_{18}$ fatty acids. The degrees of unsaturation of 74.99% for *T. esculentum,* 72.97% for *X. zambesiaca,* and 72.89% for *B. petersiana* seed oils are quite similar to many commercial vegetable oils. The principal fatty acids in all three seed oils are palmitic (16:0), stearic (18:0), oleic (18:1n-9), and linoleic (18:2n-6).

*Tylosema esculentum* and *X. zambesiaca* seed oils have oleic acid as the most abundant fatty acid, 47.61 and 64.53%, respectively. *Bauhinia petersiana* seed oil, on the other hand, has linoleic acid as its most abundant fatty acid, 44.82%. *Xanthocercis zambesiaca* seed oil differs slightly from the other two by having a small amount of linolenic acid (5.32%), and it also has detectable amounts of longer-chain fatty acids (22:0, 24:0, and 26:0). In general, however, the degree of total unsaturated fatty acid composition is quite similar in all three seed oils.

**TABLE 2**
**Fatty Acid Composition of the Leguminosae Seed Oils as Determined by Capillary Gas Chromatography[a]**

| Fatty acids | *T. esculentum* | *X. zambesiaca* | *B. petersiana* |
|---|---|---|---|
| 14:0 | 0.13 | 0.03 | 0.07 |
| 16:0 | 12.09 | 12.76 | 16.35 |
| 17:0 | 0.09 | 0.09 | |
| 18:0 | 6.75 | 7.04 | 6.80 |
| 20:0 | 2.76 | 1.40 | 0.52 |
| 22:0 | — | 1.66 | — |
| 24:0 | — | 2.65 | — |
| 26:0 | — | 0.37 | — |
| 16:1n-7 | 0.38 | 0.31 | 0.27 |
| 17:1 | — | 0.06 | — |
| 18:1n-9 | 47.61 | 63.37 | 26.28 |
| 18:1n-7 | 1.67 | — | 1.30 |
| 20:1n-9 | 0.57 | 0.79 | 0.23 |
| 18:2n-6 | 26.43 | 2.77 | 44.82 |
| 18:2n-x | — | 0.34 | — |
| 18:3n-3 | — | 5.32 | — |
| Minor | 1.54 | 1.04 | 3.40 |
| Saturated | 21.82 | 26.00 | 23.73 |
| Monounsaturated | 48.56 | 64.53 | 28.07 |
| Diunsaturated | 26.43 | 3.12 | 44.82 |
| Triunsaturated | | 5.32 | |

[a]See Table 1 for abbreviations.

**TABLE 3**
**Composition of Fatty Acid Classes in the Seed Oils from *T. esculentum* and *X. zambesiaca*, Estimated from Integrals of $^1$H Nuclear Magnetic Resonance Signals[a]**

| | *X. zambesiaca* | | *T. esculentum* | |
|---|---|---|---|---|
| Proton signal | Chemical shift (ppm) | Integral | Chemical shift (ppm) | Integral |
| Olefinic | 5.32 | 10.26 | 5.35 | 11.07 |
| *sn*-1 + *sn*-3 | 4.12–4.31 | 7.53 | 4.12–4.26 | 9.51 |
| Doubly allylic | 2.79 | 1.58 | 2.75 | 3.75 |
| Allylic | 2.05 | 17.22 | 2.01 | 22.42 |
| Methyl | 0.85 | 15.78 | 0.89 | 21.46 |
| Methyl (n-3) | 0.91 | 0.85 | | |
| Estimated amounts of fatty acid classes | | | | |
| α-Linolenic | 5% | | | |
| Diunsaturated | 10% | | 26% | |
| Monounsaturated | 67% | | 52% | |
| Saturated | 18% | | 22% | |

[a]See Table 1 for abbreviations.

The composition of the fatty acid classes in the oil samples, as determined by capillary GC (Table 2), is in close agreement with $^1$H NMR analysis of the seed oils from *T. esculentum* and *X. zambesiaca*. In the NMR analysis, the fatty acid classes were estimated from the proton signals in the olefinic region. Tables 2 and 3 show the close agreement between the data collected from GC and $^1$H NMR analyses. Thus, the NMR analysis further confirms the nature of the Leguminosae seed oils.

The data collected in this work are sufficient to allow classification of the seed oils from *T. esculentum, B. petersiana,* and *X. zambesiaca* among such commercial oils as groundnut, cottonseed, and rapeseed. The high levels of mono- and diunsaturation in these seed oils confirm their usefulness as food sources. The reasonably good yields of the seed oils from *T. esculentum, X. zambesiaca,* and *B. petersiana,* together with their attractive general properties, make these Leguminosae seeds good candidates for further studies to evaluate their future economic prospects in the Southern African region.

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