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Food Security and Nutrition in Mozambique: Comparative Study with Bean Species Commercialised in Informal Markets

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Abstract: In Mozambique (South-eastern Africa), *Phaseolus vulgaris* and *Vigna* spp. are important staple foods and a major source of dietary protein for local populations, particularly for people living in rural areas who lack the financial capacity to include meat in their daily dietary options. This study focuses on the potential for improving diets with locally produced nutritious legumes whilst increasing food security and income generation among smallholder farmers. Using bean species and varieties commercialised as dry legumes in the country, it sets out to characterize and compare the chemical properties of *Phaseolus vulgaris* and *Vigna* spp. among the most commercialised dry legume groups in Mozambique. The principal component analysis showed a clear separation between *Phaseolus* and *Vigna* species in terms of proximate composition, whereas protein content was quite uniform in both groups. It concludes that the introduction of improved cultivars of *Phaseolus vulgaris* and *Vigna* species maize–legume intercropping benefits yield, diets and increases household income with limited and low-cost inputs while enhancing the resilience of smallholder farmers in vulnerable production systems affected by recurrent drought and the supply of legumes to urban informal markets.

Keywords: East Africa; pulses; *Vigna*; *Phaseolus*; Leguminosae; malnutrition; chemical composition

1. Introduction

Legumes (e.g., *Phaseolus vulgaris*, *Vigna* spp., *Vicia faba*, *Lens culinaris*, *Cajanus cajan*, and *Glycine max*) have attracted great attention as a primary source of nutrients for millions of people throughout the world [1]. As the issue of nutrients (e.g., proteins) became part of the global nutrition debate since the 1940s, research into deficiencies focused on vulnerable populations in low-income countries have gained greater momentum over the last two decades. Reducing (multiple) nutrient deficiencies in children, the incidence of related conditions, and infant mortality rates, currently forms an integral part of the development agenda under the aegis of international agencies, partnerships and NGOs [2]. Promoting

a (greater) diversity of diets and reinforcing multiple nutrient intakes by diversifying domestic food production and the supply of affordable marketable crops such as legumes constitute prime drivers of Sustainable Development Goals (SDGs) 1, 2 and 3 [3].

Of all beans of the Leguminosae family, the *Vigna* and *Phaseolus* are the best-known genera, and several species are among the most used beans in Africa, playing an important role in smallholder farmers' income generation and food security in many countries (e.g., Latin America and the Caribbean) [4,5]. *Vigna subterranea* and *V. unguiculata* are native to the African region, whereas *Phaseolus vulgaris* and *Vigna radiata* originate from Latin and Central America, and India, respectively. Currently, they are extensively cultivated all over the world [6–9]. These beans have a high nutrient value, are crucial for nutritional and food security, and reduce mal- and sub-nutrition levels in developing countries, above all in sub-Saharan Africa [10,11] but also in densely populated countries such as India [12].

The consumption of dry legumes, including *Vigna* spp. (e.g., *V. radiata* or mung bean), *V. subterranean* (bambara-nut), *V. unguiculata* (cowpea) and several cultivars of *Phaseolus vulgaris* (common bean), contributes to the treatment of and has a protective effect against some degenerative chronic diseases, such as diabetes, cancer, obesity, neoplasms, and cardiovascular diseases [13–15]. *Phaseolus vulgaris* and *Vigna* spp. are important and affordable sources of vitamins, carbohydrates, minerals, energy, proteins, dietary fibres and essential amino acids for people living in developing and developed countries [11,16–18]. In Latin America and Africa (including Mozambique, see Figure 1), *Phaseolus vulgaris* and *Vigna* spp. are important staple foods and a major source of dietary protein for local populations [19], particularly for people living in rural areas who lack the financial capacity to include meat in their daily dietary options. Therefore, dry beans are also called "poor man's meat" as legume grains are rich in protein (ranging from 17% to 30%) [10,16,20,21]. Belonging to the Fabaceae family, the majority of *Phaseolus* and *Vigna* species can fix atmospheric nitrogen through symbiosis with nitrogen fixing bacteria [22]. Thus, the beans are a valuable crop species for crop consociation or crop rotation and have useful components for agroforestry systems [23].
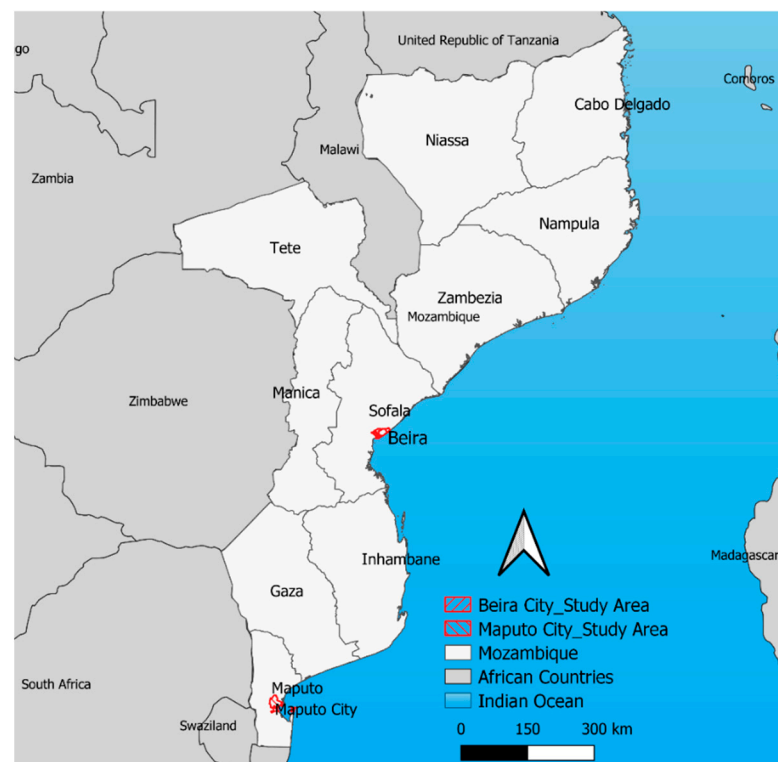

Figure 1. Geographic location of study area.

Several *Phaseolus* and *Vigna* species comprise different varieties and/or cultivars, with distinct crop needs and organoleptic properties. For instance, *Vigna* species are drought-tolerant crops, resistant to pests and diseases, and thrive under harsh environmental conditions [24,25]. In Mozambique, *Vigna* species such as *V. unguiculata* usually grow in smallholders' fields, home gardens, backyards and sometimes grow in the wild. Moreover, the leaves of this legume are edible, and the immature pods and seeds can also be consumed as a vegetable. The nutritional value of dry beans has been the subject of studies in several parts of the world, including the US, UK, Sultanate of Oman, China, India, Brazil, and Poland [1,20,26–29]. In Africa, the importance of pulse crops (i.e., edible seeds of plants from the Leguminosae family), including the common bean, for food and nutritional security has been recognised, as well as yield, marketing, and consumption patterns, and the key role of smallholder farming in this respect [30–33]. Regional research networks have been set up in Africa, including the East and Southern African Bean Research Network (ECABREN), to promote new technologies for seed breeding, multiplication, and delivery. Nevertheless, published research on the nutritional value of highly nutritious crops such as dry beans in Eastern and Southern African regions remains rare, and the few available studies mostly focus on South Africa [34,35].

Over the last two decades, Mozambique has been the focus of projects centring on the distribution of improved seed varieties of the common bean, as well as the cowpea, groundnut, pigeon pea, and soybean, to enhance food security among smallholder producers and on improving value chains [36,37]. In addition, the country has adopted a national multi-sectoral strategy to reduce food insecurity and chronic malnutrition affecting more than 40% of children aged 0–5 years. This strategy advocates the need for improving families' access to and use of highly nutritious crops and foodstuffs [36]. Although some studies were undertaken on the common bean in Mozambique [38,39], very few studies on the laboratory characterization of the nutritional value of dry beans or their commercialisation have been published except for a summary account on the *Vigna unguiculata's* response to water stress and proline accumulation [40].

As far as we are aware, this is the first study addressing the nutritional value of *Phaseolus vulgaris* and *Vigna* spp. commercialised in Mozambican (in)formal markets (see Figure 2) with a focus on food security, dietary improvement, and poverty alleviation. The nutritional value of dry beans depends on a variety of factors, including genetic characteristics, regional variability, agroclimatic conditions, and postharvest processing [1,8]. Most of the *Vigna* spp. are legume varieties indigenous to sub-Saharan Africa, including Mozambique. Despite their importance as a traditional food source, these legumes are relatively underutilised and under-researched compared with the better-known common beans [24]. Hence, *Vigna* spp. are considered neglected food crops [41] and were recently listed as a strategic crop in Mozambique.

This study aims to contribute to the current debate on improving diets with locally produced nutritious legumes and promoting greater food security and income generation among smallholder farmers. Using bean species and varieties of most commercialised dry legumes in Mozambique, we extracted quantitative data on the nutritional composition of *Phaseolus vulgaris* and *Vigna* spp. sold in two informal markets in Maputo and Beira cities (see Figure 2). This study also provides insights into their production, consumption, and sale based on a review of the literature and observation in loco. Specifically, we aimed to characterise and compare the chemical properties of *Vigna* spp. and *Phaseolus vulgaris* cultivars, which are among the most commercialised dry legume groups in Mozambique.

Figure 2. Informal markets in Mozambique. (**A**) Maquinino informal market in Beira city, and (**B**) Zimpeto informal market in Maputo city.

2. Materials and Methods

2.1. Study Area

Mozambique comprises a surface area of about 800,000 km^2 which is divided into 11 provinces. Maputo (southern Mozambique) is the capital of the country (1.08 million inhabitants), and Beira, in Sofala province (central Mozambique), is the second largest city (552.825 inhabitants, Figure 1). According to the 2017 census [42], Mozambique's population totalled 26.99 million inhabitants (66.65% rural population), with the Maputo and Sofala regions accounting for 2.05 and 2.22 million, respectively. Smallholder farmers produce 95% of Mozambique's agricultural output and account for almost all the beans produced, mainly cultivated by women.

Given that the markets of Maputo city and Beira are the most important in the country (Figure 2), we selected the principal markets in Beira (Maquinino informal market: Figure 2A) and Maputo city (Zimpeto informal market: Figure 2B) for the purpose of this study. Maputo and Sofala markets are located in coastal regions where beans are mostly cultivated on rainfed soils. The study areas are subjected to cyclical flooding during the rainy/monsoon season (from October to March), recurrent in the Beira region and its hinterland [43]. Beans are generally grown on poor soils, often intercropped with cereals (such as maize and sorghum), cassava, or other bean species; different varieties are planted in small quantities with relatively low yields. Harvest losses are incurred owing to pests, drought, floods, and soil degradation [44]. Together with *Phaseolus lunatus* (butter beans), *Cajanus cajan* (pigeon peas), *Vigna* spp. (cowpeas), *Cicer arietinum* (chickpeas), *Vicia faba* (faba beans), and *Glycine max* (soybeans), *Phaseolus vulgaris* (common beans and black beans) are a source of cheap proteins, oils, complex carbohydrates, and vitamins for vulnerable rural communities and fast-growing urban populations in the selected study areas.

2.2. Samples and Prices

A total of eight grains' samples of dried beans (*Vigna* spp. and *Phaseolus vulgaris*) including *Vigna subterranea* var. subterranea (Bambara groundnut, MP1Vs), *Phaseolus vulgaris* (common beans, MP2Pv), *Vigna unguiculata* var. tenuis (cowpea, MP4Vu), *Phaseolus vulgaris* (black beans, MP5Pv), *Vigna radiata* var. radiata (mungbean, MP6Vr), *Phaseolus vulgaris* (common beans, SO7Pv), *Vigna unguiculata* var. unguiculata (cowpea, SO12Vu), and *Phaseolus vulgaris* ("catarino beans or haricot catarino", SO13Pv) were purchased in the Maquinino informal market in Beira, Sofala province (Figure 2A) and Zimpeto informal market in Maputo (Figure 2B). The selection of these eight bean samples was based on their local importance, place of purchase, and difference in seed quality attributes (e.g., colour, size, and shape of seeds). The initial letters "MP" and "SO" were used as acronyms for the samples of beans acquired in Maputo and Sofala (Beira) provinces, respectively. The

samples were previously chosen to select grains of beans free from defects and remove external material as well.

The price of each bean variety was recorded in local markets in new metical (MZN, Mozambican currency) and then converted into US dollars according to Millennium *Banco Internacional de Moçambique* (BIM–International Bank of Mozambique) exchange rates. The exchange rate on 23 March 2021 was: USD 1 equivalent to 71 MZN (https://www.millenniumbim.co.mz/pt/particulares (accessed on 23 March 2021)).

2.3. Chemical Analysis of Proximate Composition

Samples were analysed concerning moisture, ashes, proteins, lipids, and fatty acids (saturated, monosaturated, and polyunsaturated) and carbohydrates, dietary fibre, and energy; mostly according to the Association of Official Analytical Chemists (AOAC) and ASTM procedures. Chemical analyses were performed at the SGS Laboratory (an international and certified laboratory with global standards, https://www.sgs.com/en/certification, (accessed on 23 March 2021)), which works in partnership with the Instituto Superior de Agronomia (ISA) in Lisbon, Portugal. The moisture and ash contents were determined using a TGA701 Thermogravimetric Analyzer (LECO, EUA; Michigan) according to the ASTM D5142 standard [45]. Lipids were determined by the extraction of hexane using a Soxhlet apparatus (FOSS, soxtec 2050; Höganäs, Sweden). A Fat Extraction System (FOSS, Hillerød, Denmark) was operated according to the AOAC standards method 945.16 [46]. Fatty acids were determined by gas chromatography coupled to a flame ionization detector (GC-FID) with an Agilent 7820A Gas Chromatograph system (Agilent Technology, Santa Clara CA, USA) running GC Chemstation software (version E.02.02). The instrument was equipped with a 30 m × 250 μm × 0.25 μm column (Agilent Technology, USA), and experimental GC/FID setup that comprehended the following conditions of analysis: injector temperature (250 °C), split ratio (1:80), oven temperature (220 °C), detector temperature (270 °C), injection volume (1μL), and a flow rate of carrier gas (hydrogen) (0.7 mL/min) [47]. Protein content was measured by the Dumas combustion method (analyser LECO FP-528 LC, USA) using Windows-based software FP-528 with a default protein factor of 6.25 and AOAC Method 992.23. Energy was determined according to the ASTM D5865 standard [48]. Dietary fibre was performed through VELP system using a digester dietary fibre analyser (VELP Scientifica, Italy) in accordance with AOAC Method 991.43 (and equivalent AACC Method 32-07.01) [49]. Total sugars were determined by using the Portuguese standard 1420 and the Luff–Schoorl technique [50]. Total carbohydrates were determined by the Phenol-Sulfuric Acid Method and AOAC Method 44.1.30 [51,52]. Salt content was obtained by calculation using Volhard Titration of Chloride in Plant Material (AOAC Method 915.01) [53] adapted from AOAC International [46].

2.4. Statistical Analysis

All dry bean data were presented as mean values. The statistical analysis was performed using the RStudio program version 1.4.1106 (The R consortium, Boston, MA, USA) [54]. Since our data did not follow a normal distribution and the variance was not homogeneous, we performed a non-parametric Kruskal–Wallis test (univariate analysis) for all variables at the 95% confidence level. Principal component analysis (PCA) was performed based on the correlation matrix. The Kaiser criterion (eigenvalues higher than 1) was applied to explain the samples of beans projections on a two-dimensional graph (PC1 and PC2) [55]. All variables were auto-scaled prior to multivariate analysis (mean = 0, and standard deviation = 1). Cluster analysis (heatmap function) was performed to group the samples using the Ward hierarchical agglomerative method and Euclidean distance [56]. All chemical properties of samples of beans were measured in triplicate.

3. Results

All species are annual crops well adapted to the climate and soil conditions of Mozambique. *Phaseolus vulgaris* is native to Tropical America, but currently, several cultivars are

cropped globally, whereas the three *Vigna* species are native to tropical Africa. Prices for dry beans in the local markets at the time of acquisition were found to range from 1.11 USD/kg (SO13 Pv) to 2.7 USD/kg (MP6 Vr), showing vast differences between both types of beans and the Maputo and Beira markets (Table 1).

Table 1. Characteristics of the bean samples analysed, from the Maputo and Beira markets, Mozambique.

Species	Market (Accession)	Common Names	Price ($/kg)	Cropping and Ecology
Phaseolus vulgaris L.	Maputo (MP2 Pv)	common beans feijão manteiga	1.51	Annual twining herbs, erect. Species native to tropical America, currently and extensively cultivated all over the world. It grows well in warm temperatures and prefers a warm sunny position and well-drained soil. The roots can produce a symbiotic interaction with nitrogen-fixing bacteria.
Phaseolus vulgaris L.	Beira (SO7 Pv)	common beans feijão manteiga	1.39	
Phaseolus vulgaris L.	Maputo (MP5 Pv)	black beans, feijão-preto	2.19	
Phaseolus vulgaris L.	Beira (SO13 Pv)	feijão catarino	1.11	
Vigna radiata (L.) Wilczek	Maputo (MP6 Vr)	mungbean feijão soroco	2.7	Annual herbs, erect, twining, or creeping. This species is the main source of bean sprouts. It is widely cultivated in tropical and subtropical regions. It prefers a sunny environment, well-drained soils rich in organic matter and warm temperatures. The plant root enriches the soil with nitrogen due to symbiosis with nitrogen-fixing bacteria.
Vigna subterranea (L.) Verdc.	Maputo (MP1 Vs)	bambara groundnut feijão jogo, feijão ticochane	2.04	Annual herb with creeping stems. Native to Tropical Africa, the species is remarkably drought-resistant and is an important crop in semi-arid regions. It prefers sandy soils, warm temperatures and can produce a symbiotic interaction with nitrogen-fixing bacteria.
Vigna unguiculata (L.) Walp.	Maputo (MP4 Vu)	Cowpea, feijão nhemba-nhachengua	1.69	Annual or perennial herb, erect, trailing, or twining, native to Tropical Africa with several subspecies. It prefers a warm climate, full sunlight, and tolerates a wide variety of soils so long as they are well-drained. This species usually engages in a symbiotic relationship with nitrogen-fixing bacteria.
Vigna unguiculata (L.) Walp.	Beira (SO12 Vu)	Cowpea, feijão-nhemba	1.48	

3.1. Proximate Chemical Composition

Table 2 presents the mean values for moisture content (moist.), protein (prot.), fat, saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), total carbohydrates (TCH), energy, dietary fibre, ash content, salt, and total soluble sugars (TS). The range of values obtained for samples of beans were: from 11.8% (MP6 Vr, MP1 Vs) to 15% (SO7 Pv) for moisture; from 17.8% (MP1 Vs) to 24.4% (MP5 Pv) for protein; from 0.3 g/100 g (SO7 Pv, SO13 Pv, MP2 Pv) to 0.8 g/100 g (SO12 Vu, MP6 Vr, MP1 Vs) for SFA; from 0.2 g/100 g (SO7 Pv, SO13 Pv, SO12 Vu, MP2 Pv) to 4.2 g/100 g (MP1 Vs) for MUFA; from 0.5 g/100 g (MP6 Vr) to 1.5 g/100 g (SO7 Pv, MP2 Pv) for PUFA, from 56% (MP5 Pv) to 61% (MP4 Vu, MP1 Vs) for TCH; from 322 Kj (MP4 Vu) to 1431 Kj (MP1 Vs) for energy; from 14.1% (MP6 Vr, MP4 Vu) to 21% (MP2 Pv) for dietary fibre; from 2.95 (SO12 Vu) to 3.55% (SO13 Pv) for ash content; from 0.22 g/100 g (SO7 Pv) to 0.48 g/100 g (MP2 Pv) for salt content; and from 5.2% (SO7 Pv) to 5.7% (SO12 Vu) for TS.

<div align="center">**Table 2.** Proximate analysis of dry beans.</div>

Market/ Accession	Moist. (%)	Prot. (%)	Fat (%)	SFA (g/100 g)	MUFA (g/100 g)	PUFA (g/100 g)	TCH (%)	Energy (Kj)	Fibre (%)	Ash (%)	Salt (g/100 g)	TS (%)
Maputo												
MP1 Vs	11.8 d	17.8 d	6.2 a	0.8 a	4.2 a	1.2 cd	61 a	1431 a	14.9 d	3.05 e	0.45 c	5.6 ab
MP2 Pv	14.0 abc	20.5 c	2.0 d	0.3 b	0.2 c	1.5 a	60 ab	1251 b	21.0 a	3.38 b	0.48 b	5.5 abc
MP4 Vu	13.8 bc	20.1 c	2.3 b	0.7 a	0.4 ab	1.2 cd	61 a	322 c	14.1 e	3.01 e	0.36 d	5.3 bc
MP5 Pv	14.5 a	24.4 a	2.1 c	0.4 b	0.3 bc	1.4 ab	56 c	1247 d	20.8 a	3.26 c	0.43 c	5.4 abc
MP6 Vr	11.8 d	23.8 a	1.7 e	0.8 a	0.3 bc	0.5 e	60 ab	1343 e	14.1 e	2.99 f	0.26 f	5.0 abc
Sofala												
SO12 Vu	13.2 cd	22.0 b	2.0 d	0.8 a	0.2 c	1.0 de	60 ab	1305 f	16.9 c	2.95 g	2.14 a	5.7 a
SO13 Pv	14.4 ab	21.1 b	1.8 e	0.3 b	0.2 c	1.3 bc	59 bc	1268 g	17.1 b	3.55 a	0.34 e	5.5 abc
SO7 Pv	15.0 a	20.1 c	2.0 d	0.3 b	0.2 c	1.5 a	60 ab	1284 h	15.3 d	3.17 d	0.22 g	5.2 c

Values followed by different letters in the same column are significantly different (Kruskal–Wallis test, followed by Kruskal–Wallis post hoc test at $p < 0.05$).

3.2. Principal Component Analysis (PCA)

PCA was applied to evaluate the data of proximate composition for eight bean samples. PCA analysis showed that the first two components accounted for 75.3% (PC1–48.7% and PC2–26.6%) of total variance for the proximate composition (Figure 3).
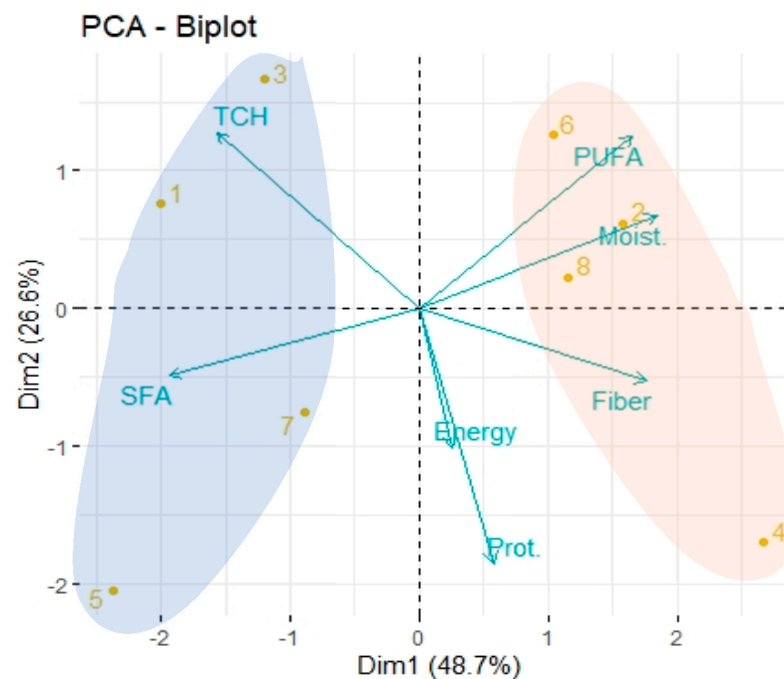

Figure 3. Biplot of the principal component analysis (PC1 and PC2) scores for eight samples of beans (proximate composition), namely: 1:MP1 Vs, 2:MP2 Pv, 3-MP4 Vu, 4:MP5 Pv, 5:MP6 Vr, 6:SO7 Pv, 7:SO12 Vu, 8:SO13 Pv.

3.3. Cluster Analysis (CA)

From the correlation matrix, heatmaps were constructed using the Ward hierarchical agglomerative method and Euclidean distance, where clusters of accessions are in the horizontal lines, whereas in the vertical lines are clusters of chemical characterisation data for seven proximate contents (Figure 4). The lowest values are displayed by dark violet boxes, while the highest values are represented by dark yellow boxes. The heatmap differentiates between two major groups of accessions, namely: *Vigna* species (Cluster 1) and *Phaseolus vulgaris* (Cluster 2). The proximate composition (Figure 4), moisture content,

protein, total carbohydrates, saturated fatty acids, polyunsaturated fatty acids, energy, and dietary fibre were analysed in eight bean samples from Beira (Sofala) and Maputo in Mozambique. Cluster 1 is related to the samples of beans that presented relatively high values of total carbohydrates and saturated fatty acids, while Cluster 2 is defined by samples that contained relatively high values of fibre, polyunsaturated fatty acids, and moisture. For both groups (Clusters 1 and 2), intermediate values of energy were found in the samples.
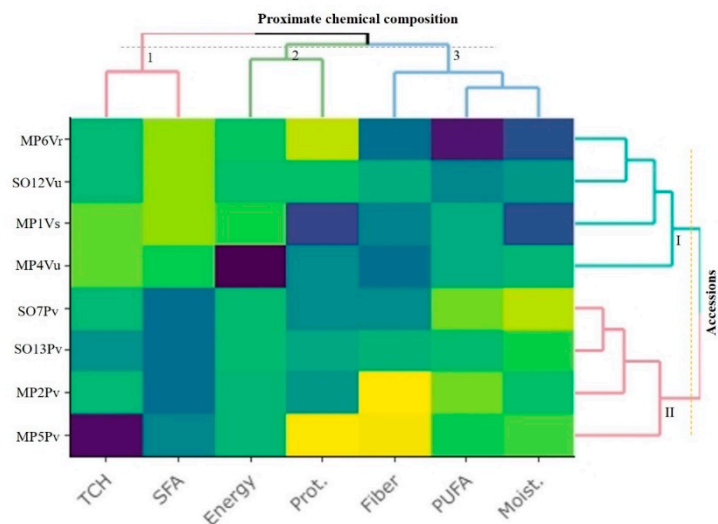

Figure 4. Heatmap of the eight accessions of dry beans (four *Phaseolus vulgaris* and four *Vigna* species) obtained from chemical characterisation data for seven proximate contents. Violet and yellow boxes indicate low values and high values, respectively.

4. Discussion

In Mozambique, beans are appreciated for their valuable nutritional properties, containing significant amounts of nutrients such as proteins, vitamins, and minerals [57]. Our study shows that *Phaseolus* and *Vigna* species can be distinguished from each other, namely in terms of proximate composition (see Figures 3 and 4). In line with our findings, a recent study conducted by Catarino et al. [58], using cluster analysis, showed a clear difference between *Phaseolus* and *Vigna* species in terms of mineral composition. Nevertheless, the protein content is quite uniform among the studied *Phaseolus* and *Vigna* species, but the samples from these two species collected in Maputo markets (i.e., MP5 Pv and MP6 Vr) revealed the highest protein content. These beans also attain the highest prices per kilogram in the local markets of Maputo, the capital of Mozambique. In general, these products present a high content of TCH (>56%), with an appreciable content of fibre (>14%) and low content of soluble sugars (<5.7%). The lipid fraction is rich in MUFA and PUFA. The global analysis allows us to conclude that *Phaseolus* and *Vigna* species are considerably balanced foods that can contribute to decreasing food insecurity.

Phaseolus and *Vigna* species and pulses in general (i.e., dry beans, dry broad beans, dry peas, chickpeas, cow peas, pigeon peas, lentils, bambara beans, vetches, and lupins) also promote sustainable agriculture, providing ecological benefits by enriching the soil with their symbiotic interaction with nitrogen-fixing bacteria, and using less water than other crops [59]. Consociated cultivation, combining *Vigna* species and other crops such as maize and sorghum, is a common practice that enriches the soil. These species have multiple applications at the household level, through the processing and cooking of seeds, pods, and leaves to prepare foodstuffs, popular local dishes as well as being commonly used in traditional medicine.

The size and composition of smallholder farms differ as do the types of agricultural systems, cultivation techniques, and marketing options [60]. Despite efforts to quantify production and characterise agricultural systems via annual nationwide agricultural surveys,

there is a lack of comprehensive data and understanding of smallholder bean production, consumption, and commercialisation patterns. Available survey data on smallholder farmers show that maize, cassava, and beans tend to rank among their principal crops and source of farmer households' agricultural revenue. One-fifth of smallholder farmers are under 30, whilst 23% of smallholder households are headed by women whose inputs are critical for both crop production and marketing. The great majority (71%) of cultivated smallholder plots are 2 ha in size or smaller. In Mozambique, the cultivated area dedicated to the production of bean species increased by approximately 50% between 2015 and 2019. In the provinces of Sofala and Maputo, the growth is above average (60%) while doubling in the Maputo region over the same period [61].

Nevertheless, acute food insecurity among farmer households worsened during the same period, and markedly so in the Sofala region. Lately, the region has been affected by the impact of the strongest and most devastating tropical cyclone, Idai (category four, 2019), ever recorded in the Southern Hemisphere [62,63], and by politico-military instability in central Mozambique. Acute malnutrition levels in the Sofala region among children between 6 months and 5 years of age are among the highest in the country, significantly higher than in the Maputo region [64]. Hence, food security for already vulnerable groups practising subsistence agriculture appears to be under threat, not in the least because more than half of smallholder households live beneath the poverty line [62]. The low intake of nutrients associated with chronic malnutrition among children under five years old is regarded as a severe health and growth risk in the country [64], prompting authorities to introduce a Multisectoral Plan for Chronic Malnutrition Reduction in 2010. Legumes, and beans and peas among them, are particularly suited to alleviate malnutrition. Evaluations of food security have revealed significant stress levels, owing to low productivity, irregular precipitation, limited knowledge of food stock management, and a lack of quality and improved seeds. Nevertheless, diet adequacy in the Sofala and Maputo regions appears to be higher than the national average [36,65].

Phaseolus vulgaris and *Vigna* spp. are the most common legumes for sale in local markets, both in Beira and Maputo, and are the most consumed and incorporated in traditional dishes. The *Vigna* spp. are less care-demanding and cropped in rural homesteads, while *Phaseolus vulgaris* is typically found in urban vegetable gardens. However, the volume of production of *Vigna radiata* and *V. subterranea*, especially the latter, is considerably smaller than that of the common bean in Mozambique. The prices were recorded at the Maputo and Beira markets, where the beans are sold in small quantities. Most consumers can probably obtain beans at lower prices from other sources (e.g., wholesale markets) or crop them in vegetable gardens, subsistence or smallholder farming. The prices fluctuate according to the seasonal cycle, being the lowest just after the harvest period when the supply is greater, and highest during the dry season, especially in the dryer areas such as the south of Mozambique.

At the time of fieldwork, a greater diversity of beans was observed in Maputo's than in Beira's markets. *Vigna radiata* and *V. subterranea,* and black beans were mostly found in Maputo, yielding higher prices. While prices per kilogram were generally higher in Maputo, the most expensive beans in the capital (black beans, mung bean, and bambara groundnut) were much less common in Beira, reflecting differences in purchasing power and consumer preferences. Higher prices are quoted for *Vigna radiata* and *V. subterranea*. Overall, the marketed beans seem to be rather expensive for local consumers and many families' budgets.

Published studies on the marketing of crops in informal markets are rare, limited to a few project reports. The Ministry of Agriculture (MINAC) implemented a price information system for several agricultural commodities (SIMA), but most smallholder farmers have difficulty accessing the information, owing to their limited access to mobile phones and networks.

For smallholders, whilst most crops are produced for domestic consumption, smaller portions are sold for cash or bartered. Hence, legume markets constitute important outlets

for generating household income for smallholders [66]. In this respect, beans rank among the crops with the largest share of harvests destined towards revenue generation, on par with maize [62]. Despite beans' importance as a key dietary component, and their broad acceptance, market prices appear to be rather high for the purses of many Mozambicans, affecting, above all, economically vulnerable populations such as those in the study areas. Hence, priority should be given to promoting better linkage between producers and end consumers by improving the performance of (informal) marketing circuits, limiting the role of intermediaries, and enhancing understanding of consumer preferences in urban markets. As a result, producers will be able to better adapt to production on demand and thus reap greater benefits for themselves and their dependents.

Very few studies have been conducted on value chains for legumes - and beans in particular - which include informal markets [66,67]. Most smallholders sell their produce directly to their local clients and to a lesser extent via intermediaries, such as wholesale or retail agents. In terms of crop marketing, the fact that beans are the most stocked crops following maize [62], increasing farmers' stock capacity may augment income from the sale of beans in (in)formal markets [67]. However, limited smallholder household access to land, labour, funding, and income act as constraints upon the production, investment, and quality levels, whilst seasonal factors contribute to considerable price fluctuations and varying returns.

5. Conclusions

The smallholder production of agricultural commodities in Mozambique, which accounts for more than 95% of national output, forms the basis of populations' food security. Nevertheless, despite its importance, smallholder production of legumes, and bean species in particular, and their contribution to local diets remains under-researched and under-supported; notwithstanding the fact that *Phaseolus* and *Vigna* bean species rank among the most complete and balanced food products in terms of nutrients in Mozambican diets, constitute key ingredients in local dishes requiring relatively limited and low-cost inputs and are in great demand in accessible, informal urban markets as this study demonstrates. The introduction of improved cultivars of *Phaseolus vulgaris* and *Vigna* species would render greater yields and increase revenue from smallholder plots whilst diversifying diets with the aid of key proteins, fibres, MUFA, and PUFA. Given the existence of significant levels of sub- and malnutrition in Mozambique, including the study areas set in vulnerable farming systems, increasing the availability of beans at affordable prices would undoubtedly benefit populations', health, diet, and food security.

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