Journal of Herbs, Spices & Medicinal Plants

ISSN: 1049-6475 (Print) 1540-3580 (Online) Journal homepage: www.tandfonline.com/journals/whsm20

Ethnobotanical survey of plants used in the Maasai food system and traditional medicine against gout and associated conditions in Monduli-Tanzania

Richard P. Clement, Joseph Runyogote, Jofrey Raymond & Musa N. Chacha

To cite this article: Richard P. Clement, Joseph Runyogote, Jofrey Raymond & Musa N. Chacha (2024) Ethnobotanical survey of plants used in the Maasai food system and traditional medicine against gout and associated conditions in Monduli-Tanzania, Journal of Herbs, Spices & Medicinal Plants, 30:4, 386-412, DOI: 10.1080/10496475.2024.2369874

To link to this article: https://doi.org/10.1080/10496475.2024.2369874

JOURNAL OF HERBS, SPICES & MEDICINAL PLANTS
2024, VOL. 30, NO. 4, 386–412
https://doi.org/10.1080/10496475.2024.2369874

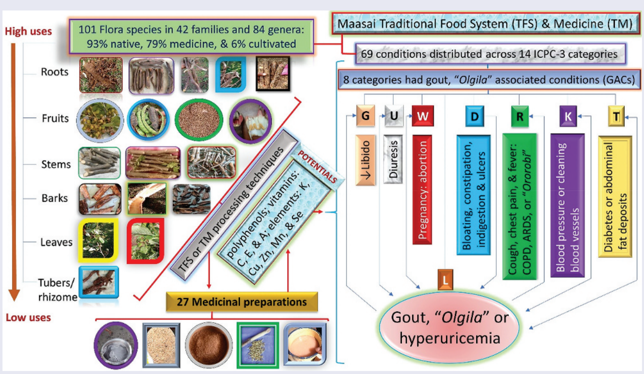
Ethnobotanical survey of plants used in the Maasai food system and traditional medicine against gout and associated conditions in Monduli-Tanzania

Richard P. Clement [a,b], Joseph Runyogote [c], Jofrey Raymond [a], and Musa N. Chacha [a]

[a]School of Life Sciences and Bioengineering, The Nelson Mandela African Institution of Science and Technology, Arusha, Tanzania; [b]Mkwawa University College of Education, A constituent College of the University of Dar es Salaam, Iringa, Tanzania; [c]Natural Sciences, Mbeya University of Science and Technology, Mbeya, Tanzania

ABSTRACT

An ethnobotanical survey was conducted to determine the plant species used against gout and gout-associated conditions (GACs) in Monduli, Arusha, Tanzania. The survey that involved 21 Maasai traditional food system (TFS) and traditional medicine (TM) practitioners revealed that the study area had 101 plant species distributed in 84 genera and 42 families. About 79% of the species were used as medicine; some were used as food or for processing. The medicinal plants (MPs) managed 69 health conditions including gout, "*Olgila*" and GACs. The MPs had potential nutritional and antioxidant agents against diseases including metabolic diseases (MDs), like gout. The root parts of the plants (54% species) were exploited the most; most plants (94%) were sourced from the wild. Integrated conservation and promotion measures are needed to prevent loss of TFS and TM knowledge.



ARTICLE HISTORY
Received 1 April 2024

KEYWORDS
Ethnobotany; food system; metabolic diseases

CONTACT Richard P. Clement clementr@nm-aist.ac.tz; richardclement28@gmail.com School of Life Sciences and Bioengineering, The Nelson Mandela African Institution of Science and Technology, P. O. Box 447, Arusha, Tanzania

Supplemental data for this article can be accessed online at https://doi.org/10.1080/10496475.2024.2369874.

Introduction

Use of plants in a traditional food system (TFS) and traditional medicine (TM) promotes the health and well-being of people in low-income countries who cannot afford modern medicine.[1,2] Thus, use of plants in TFS and TM may potentially contribute to achieving the sustainable development goal, SDG 3: good health and well-being.[3] Indigenous peoples (IPs) use the plants in multi-contexts without distinction between food and medicine for their health and well-being.[4] Thus, plants used in TFS with medicinal roles also support TM of the IPs.[4,5] About 80% of the people in low-income countries, including Tanzania, rely on TM plants for their primary healthcare.[6–8]

Despite various efforts to achieve SDG 10: Reduced inequalities, disparities are on the rise.[9] These structural inequalities have caused many IPs to lose access to their land and natural resources that support their TM and livelihood.[10,11] Consequently, most IPs have adopted new ways of life including progressive replacement of TFSs with a Globalized food system (GFS).[12] Since the loss of TFS could also mean the loss of TM, loss of TM or TFS at the expense of GFS is associated with food insecurity and negative health consequences.[13,14] GFS is characterized by high saturated fats, animal-based protein, sugars, refined foods, and low fibers.[12,15] Consumption of such diets in GFS is known to speed the development of metabolic diseases (MDs) including gout and its associated conditions, GACs.[15,16]

Gout is an inflammatory rheumatic disease, a consequence of hyperuricemia, an increased level of serum uric acid, which precipitates into monosodium urate in body tissues.[16] It ranks as the fourth highest global burden.[15,17] Gout can be predisposed by other MDs including cardiovascular diseases, hypertension, diabetes, and chronic kidney diseases (CKD) in addition to GFS, the predisposing factor to most MDs.[18–23]

Although the Maasai community has high consumption of fats and animal-based protein diets that are derived from their livestock,[5] they are reported to have a low prevalence of MDs including gout and GACs.[1,14] Although many IPs lost their cultural practices due to the structural inequalities, Maasai in rural areas with access to their natural resources are among IPs who still uphold their cultural practices.[1,5] The plants used in the TFS are also reported to promote the health of the IPs and keep a low prevalence of MDs in the Maasai community.[5] Plants used in TFS or TM are good sources of non-enzymatic antioxidant system: vitamins C, E, and β-carotene; trace elements Cu, Zn, Mn, and Se; and polyphenols that support the body' defense system against oxidative stress[15,16]; rich sources of macronutrients including potassium with protective or therapeutic effects against various MDs.[24] This study conducted an ethnobotanical survey to determine the kind, roles, relative importance, and conservation status of the plants used in Maasai TFS and TM against gout, GACs, and the disease risk factors in Monduli, Arusha, Tanzania.

Materials and Methods

Description of the Study Area

This study was conducted in Monduli, which is among the seven districts of the Arusha region situated between latitude 3°.29′ 59″ south and longitude 36°.45′27″ east in the northeastern part of Tanzania[5] (Fig. 1). The study area was chosen because the Maasai are the main residents who constitute 97% of all communities in the district.[5,25] Besides, nearly 70% of the Maasai live in rural areas with available natural resources that support cultural practices in their TFS, TM, and livelihood.[4,26] Monduli has 20 wards and 62 villages. This study was conducted in seven villages found in four wards: Lepurko, Makuyuni, Monduli, and Mwandeti (Fig. 1).

Monduli's climate constitutes three zones: highlands, flat and rolling plains, and rift valleys. Highland has an average altitude of 2000 m, and low land (flat and rolling plains) has an altitude ranging from 600 to 1200 m above sea level. Monduli has a dry climatic condition accompanied by warm temperatures (20–35°C) at low altitudes and cool temperatures (15–19°C) at high altitudes. Its annual rainfall ranges from <500 mm in the lowlands to 900 mm in the highlands. The Maasai mainly practice livestock keeping and some small-scale farming for their livelihood[4,26]

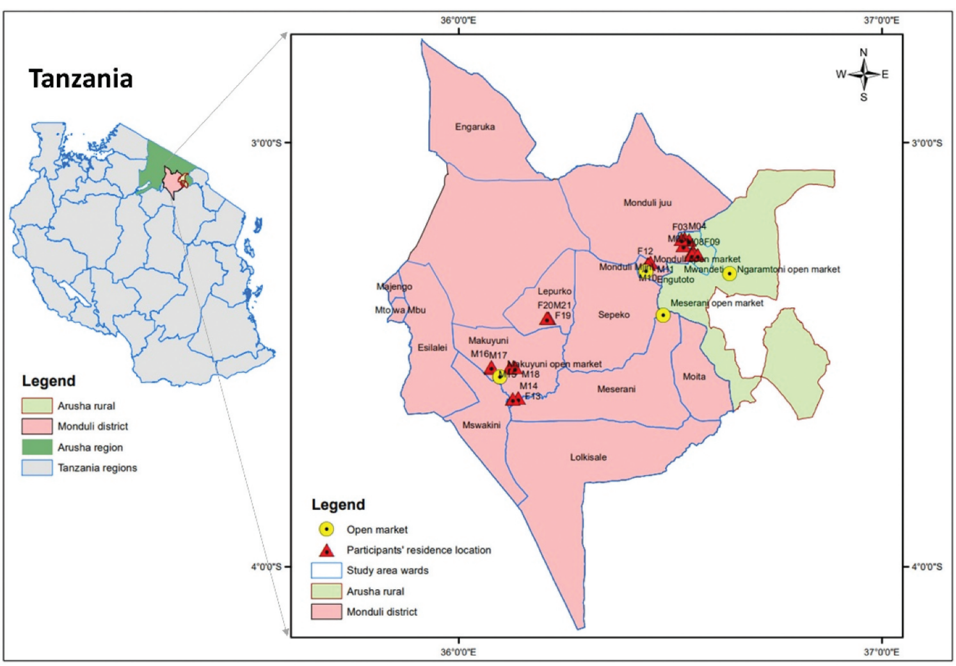


Figure 1. Participating Maasai traditional practitioners (MTPs) residences and open market locations in the selected study sites in Monduli, Arusha.

Reconnaissance Survey and Informant Selection

The survey was started in June 2020 and completed in August 2020. The collection of voucher specimens ended in April 2021. A total of 14 local administrators were consulted 2–3 d before face-to-face interviews with MTPs. The theme of the research was first introduced to the administrators for them to recommend suitable MTPs who could best participate and provide reliable information. Bias in choosing participants was avoided by guiding the administrator's recommendations to the criteria for including or excluding the participants and matching with the qualities possessed by the potential participants based on their age and experience of practicing the Maasai TFS and TM. The Maasai elders have the knowledge and experiences in their cultural practices through training organized at different stages of life and rituals like "*orpul*."[5,27]

At the age of 30 y or above, Maasai men have gathered adequate knowledge and skills on their cultural practices including TFS and TM through learning in different stages of life: boy (uncircumcised) and "*moran*," marked by circumcisions at the age around 15 years.[5] After the completion of the "*moran*" stage at the age of 30 y, Maasai men qualify for marriage to become "*muruo*" or elders who are capable of family and community responsibilities.[5] After marriage, a man provides a herd of milk cows for his wives for milk and meat for the family.[5] He also takes a herd of cows, goats, and or sheep to a distant area for grazing especially during dry seasons.[5] This can be supported by the "*moran*" if present in his family. Also, in teamwork with "*moran*," or other elders he slaughters the livestock for meat for family, cattle camps, or various rituals: birth, circumcisions, marriage, "*orpul*."[4,5] Women acquire knowledge and skills in their cultural practices through interaction with their mothers and grandmothers, and occasionally through "*orpul*."[4] A woman at the age of being married usually after menarche is capable of taking on family and community responsibilities.[5] A married woman "*tɔmɔnɔ́k*" milks the cow, processes the milk into butter for food or medicine, prepares meat from the livestock slaughtered by men, wild plants, or traditionally cultivated plants harvested.[4,5]

Based on this background, to ensure adequate information about the Maasai TFS and TM is collected, participants recruited were: aged 30 y or above, experience of practicing TFS and TM signified by involvement in rituals like "*orpul*" and cultural marriage, and family responsibility as father and mother. These participants were considered experts who practice their TFS and TM; thus, they were referred to as Maasai traditional practitioners (MTPs).

A total of 21 MTPs (15 males and 6 females) were identified from seven villages: Engalaoni, Imbibia, Lemiyoni, Lossimingori, Makuyuni juu,

Table 1. Demographic Data of the Massai Traditional Practitioner Informants (MTPs) in Monduli District, Arusha Region, 2021

Demographic data (*N* = 21)	Frequency (%)			
Gender				
Male	15 (71)			
Female	6 (29)			
Education status				
Nonformal	11 (52)			
Basic reading and writing skills only (adult education)	3 (14)			
Elementary school (STD I – IV/VII)	7 (33)			
Ethnicity				
Maasai	21 (100)			
Occupation of MTPs				
Agro-pastoralist (AGP)	18 (86)			
Agro-zerograzing (AGZ)	3 (14)			
Traditional Healer (TH)	2 (10)			
Traditional Midwife (TMW)	3 (14)			
Years of Experience (range)	AGP	AGZ	TH	TMW
<10 years (least experience was 8 years)	1 (5)	0	0	0
10–20 years	4 (19)	0	0	0
More than 20 years	13 (62)	3 (14)	2 (10)	3 (14)

Mlimani, and Zaburi (Fig. 1). Since men were free to decide their participation in the study while women's participation was influenced by their husbands' consent, women were fewer than men. The MTPs aged between 30 and 97 y (mean±SD = 66.90 ± 17.98) were a combination of agro-pastoralist, agro-zero-grazing, traditional healers (TH), and traditional midwives (TMW) who were knowledgeable of the TFS and TM (Table 1). During the interviews, the knowledge of TFS and TM was shared and recorded at the choice of MTPs.

Ethnobotanical Data Collection

This study was conducted per Bennett's Golden Rule for Ethnobotany Field Work,[28] approved by the Nelson Mandela African Institution of Science and Technology (NM-AIST) and endorsed by NM-AIST and Monduli-Tanzania Forest Service. The aim of the study and the criteria for inclusion/exclusion from the study were clarified and participants who provided informed consent were enrolled.

The data was collected through open-ended, semi-structured interviews. A checklist of open-ended interview questions translated into Swahili was used to interact with the MTPs; a Maasai translator was used for the MTPs who could not speak Swahili. The interview started at the household of each of the MTPs to obtain the available information about TFS and TM. Each MTP was visited and interviewed thrice to ensure the consistency of the data provided. The collected data at the household guided the field walks in the local environment of MTPs to obtain additional data about the species used in the Maasai TFS and TM. Then, all interviews and discussions conducted in Maasai and Swahili languages were transcribed into English.

The interviews at the households of respondents and later in the field walk generated the following data: local name of the plant species, growth habitats, habits, part(s) of the plant used, mode of plant preparations or applications, roles of the plant or preparations thereof, and ailments or health conditions managed by the plant. The data were later subjected to classical ethnobotanical systematic analysis and a numerical quantitative approach to determine the importance of plants used in the TFS and TM for primary healthcare of the IPs.[6,29]

Plant Specimen Collection and Identification

Through the guidance and assistance of a botanist and the MTPs during field walks, the plant voucher specimens were collected from June 2020 to April 2021. The GPS facility was used to record the coordinates and altitude of places from which specimens were collected. The specimens were numbered, assigned Maasai names, pressed, and dried. Appropriate documentation was made with photographs of the area and the mature individual plant at the site of collection. Identification of the specimens was done using Plant of Tropical East Africa[30] at Tanzania Plant Health and Pesticides Authority (TPHPA) in the National Herbarium section. Specimens were deposited at TPHPA in the National Herbarium section.

Data Analysis

Data were analyzed using the classical ethnobiological systematic investigation and a numerical quantitative approach.[6,29] Quantitative analysis was achieved through the following indices:

Use Categories

Species used in the TFS were grouped into use categories as found in the TFS. The use categories were formulated as described.[31,32] Each time a species was mentioned as "used" by an informant it was counted as one (1) "use report." Also, when an informant used a species for more than one role in a use category, for example, "respiratory system" for treating "cough," and or "tonsillitis," it was still counted as one "use report."[31]

Use Value (UV) Index

It is a quantitative measure that facilitates the evaluation of the relative importance of each species; it is based on the known local uses of each species among informants and it is expressed by the following equation[6]:

$$UV = \frac{\sum U_i}{N}$$

where U_i represents the number of use reports cited by each informant for a given species; and N denotes the total number of informants. Although it is used to evaluate the relative importance of species, UV does not distinguish between a single or multiple use of a plant species. The importance of each species is a function of the increase in UV values. Higher values suggest that the species are highly valuable and vice versa.

Informant Consensus Factor (ICF)

The knowledge homogeneity among informants was measured using the ICF technique[29]:

$$ICF = \frac{N_{ur} - N_s}{N_{ur} - 1}$$

where N_{ur} denotes the total number of use reports in a use category and N_s denotes the number of species cited by informants in that use category. When ICF is close or equal to zero (0) it suggests a random selection of species; there is no exchange of information among informants about species in a given use category; there is strong disagreement among informants due to different experiences and strict information keeping.[29,31] However, as ICF approaches to one it signifies a systematic well-defined selection of species; there is a clear exchange of information among informants; and the majority of informants provide information on a few species.[29,31]

Fidelity Level (FL)

The ratio of informants who independently "report the uses of a species" or "cite a health condition" for the same "use category" or "disease category" to the total number of informants who "mention the species for any use" or "cite the disease category of the health condition," respectively is determined by FL expressed below[29]:

$$FL(\%) = \frac{N_p}{N} \times 100$$

where N_p is the number of informants who "claim the use of a species for a particular purpose" or "cite a health condition;" and N is the total number of informants that "use the species for any use" or "cite the disease category of the health condition," respectively.[29]

Relative Frequency of Citation (RFC)

It showed to what extent "a species" or "a health condition" was cited "for any use" or "among health conditions," respectively, by the participants:

$$\text{RFC} = \frac{\text{FC}}{\text{N}}$$

FC is the number of informants "reporting the uses of a particular species" or citing a health condition, and N is the total number of informants.[6]

Specific Relative Frequency of Citation (RFC_s)

The $\mathbf{RFC}_s$ were computed to determine and compare the relative importance of using a plant species for a specific purpose as:

$$\text{RFC}_S = \text{FL} \times \text{RFC} = \frac{N_p}{N} \times \frac{\text{FC}}{\text{N}}$$

$$\textbf{Note} : N = \text{FC}$$

Thus, a species is important and mostly preferred by informants to treat an ailment or perform a particular role in the area when FL and RFC*s* are high, and *vice versa*.

Results

Plants Used in Maasai TFS and TM

This study recorded 101 plant species distributed in 42 families and 84 genera (Table S1). The most represented families were Fabaceae followed by Euphorbiaceae, Rutaceae, and Solanaceae: they had the highest number of species (Table S1). The habitats of the plant species: forest (52%), savanna (33%), bushland/shrubland (10%), grassland (7%), and wetland (2%) (Table S1). The plant habits: tree, T (47%); shrub, Sb (25%); herbs, H (22%); and climber, Cl (9%) (Table S1). Plants constituted native (93%) and alien species (7%) introduced and naturalized in the study area (Table S1). Six percent (6%) of the plant species were cultivated in farms, home gardens, or synanthropic, growing around MTPs' home environment (Table S1). Moreover, 58% of plant species were present in the International Union of Conservation of Nature (IUCN) red list, and the Least Concern (LC) category thereof had the highest number of species (57). The near-threatened (NT) and vulnerable (VU) categories had one species each (Table S1).

The plants of the study area had various uses and use reports (UR) respectively: medicine, 79% (276); food processing/storage materials, 32% (169);

food, 29% (135); and other uses, 8% (17) (Table S1). Among the plant species investigated in this study, *Withania somnifera* had the highest use value (**UV**) of 2.67. The plant uses were achieved by various plant parts in powder or small pieces at varying species' percentages and use reports (UR), respectively: roots (Rt), 54% (213); fruits (Ft)/seeds (Sd), 35% (171); stem (St), 31% (112); bark (Bk), 25% (59); leaves (Lf), 23% (71); rhizome (Rz)/tuber (Tb), 5% (10); and whole aerial parts (Wp), 5% (6) (Table S1). The plant parts were prepared in various ways such as mixing plant part(s) with or without food substances, minerals, and or fluid (Fig. 2). A decoction in meat broth or stock ("*olchani-imotori*") had the highest percentage of species prepared in that form (Fig. 2).

A decoction or an infusion was prepared from a plant part for a specific role. The reason(s) for mixing a decoction or preparing an infusion with food substance(s) or other fluid (Fig. 2) was to: dissolve fats, add taste or flavor, increase mixture viscosity, reduce plant side effects, enhance diffusion into the body, and or increase the efficacy in performance (Table S1). "*Opururua*" usually combines honey, a decoction from plant parts, and infusion of "*Osukuroi*" roots and some plant parts retained in the resulting mixture, "*Opururua*" (Fig. 2 & Table S1). Handcrafted plant parts were often used to process or store medicines or foods (Table S1). Furthermore, the preparations of the plant parts used in the study area were taken through different routes:

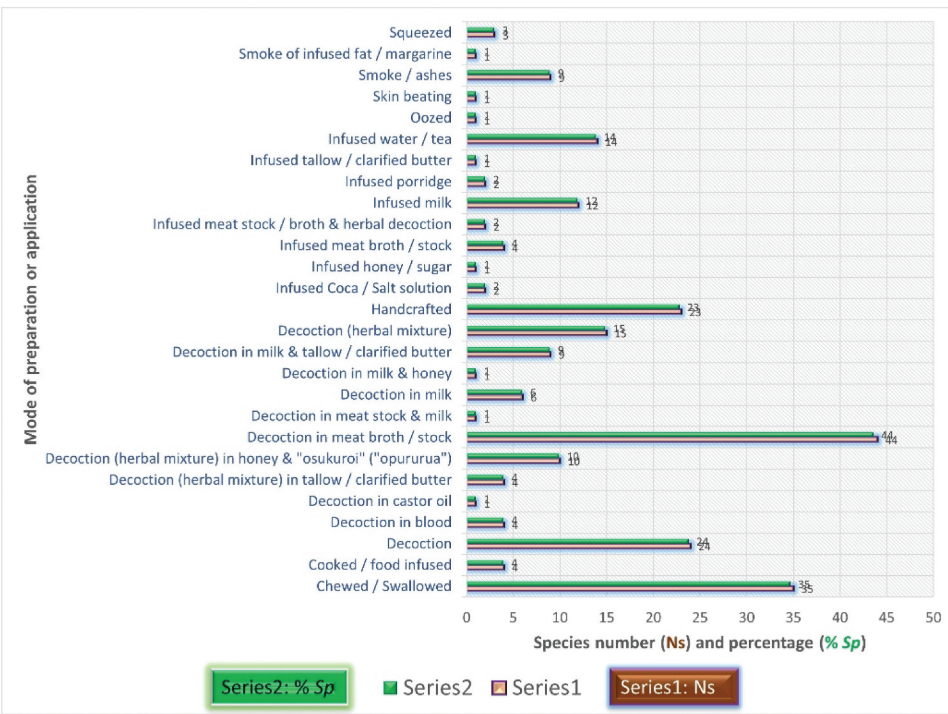


Figure 2. Proportions of plant species across modes of preparations or applications by the Masai traditional practitioners (MTPs).

oral (Or), 91%; nasal (Na), 8%; dermal (De), 7%; and ocular (Oc), 1% at varying dosages based on sex, age, body fitness, health history, duration of the sickness, pregnancy, and menstruation or menopause status. The common dosage measurements of the preparations were drops, palm length or volume, teaspoon, tablespoon, "*Mollel*" (~¼ Liter), "*Neing'asha*" or "*Laiser*" (~½ Liter), "*Leseri*" or "*Tumberi*" (~1 Liter).

Health Conditions or Ailments Managed by Plants of the Study Area

A total of 69 health conditions or ailments managed by the plants of the study area were recorded (Table S1). Classification of the conditions or ailments through the International Classification of Primary Care (ICPC-3) resulted in fourteen (14) ICPC-3 categories (Fig. 3) with informant consensus factor (ICF) ranging from 0.000 to 0.714 (Fig. 3).

Some health conditions across the ICPC-3 categories had Maasai names and some were grouped into categories classified traditionally (Table S1). Hernia, signified by stomach grumbling and pain on the umbilical cord was known as "*Enarposeseni*," representing the digestive system (**D**) conditions. Increased confidence or angriness was referred to in Maasai as "*Mori* or *Emboshona*," representing conditions of the psychological, mental, and neurodevelopmental (**P**) category (Fig. 3). Some diseases or health conditions were classified traditionally into local categories: "*Osupetai*," "*Olgila*," and "*Ororobi*."

"*Osupetai*" had the health conditions constituted in general (**A**), digestive (**D**), genital (**G**), circulatory (**K**), musculoskeletal (**L**), neurological (**N**), and respiratory (**R**) systems as well as skin (**S**) ICPC-3 categories (Figs. 3–4). Gonorrhea, boil, followed by back pain, bone pain, joint pain, and swollen joints had the highest **FL** and **RFC** (Fig. 4). "*Osupetai*" had various causes or risk factors (Fig. 5). Sexual intercourse or blood contact followed by eating foods without cleaning (detoxifying) the body or taking herbs had the highest **FL** and **RFC** (Fig. 5). "*Osupetai*" was further classified into sub-categories based on effects or affected body parts: bones ("*loloik*"), muscles, joints, and reproductive system (e.g., gonorrhea) "*Osupetai*" (Table S1). The plant species (Fig. 6 & Table S2) were used to manage "*Osupetai*" health conditions (Fig. 4).

"*Olgila*" had health conditions in the **A**, **G**, **K**, and **L** ICPC-3 categories (Fig. 7a); most of them were part of **L** conditions (Fig. 7b). Joint pain followed by body tiredness or weakness, and walking difficulties had the highest **FL** and **RFC** (Fig. 7a). "*Olgila*" had various causes or risk factors (Fig. 8). Eating without working or cleaning the body followed by eating meat with added salt, and less or lack of physical activities had the highest **FL** and **RFC** (Fig. 8). "*Olgila*" was sometimes used to refer to gout as per six respondents. Also, "*Olgila*" was sometimes used to refer to "*Osupetai*" as per seven respondents. "*Olgila*" and **L** conditions were managed by selected plant species (Fig. 9 and Table S1).

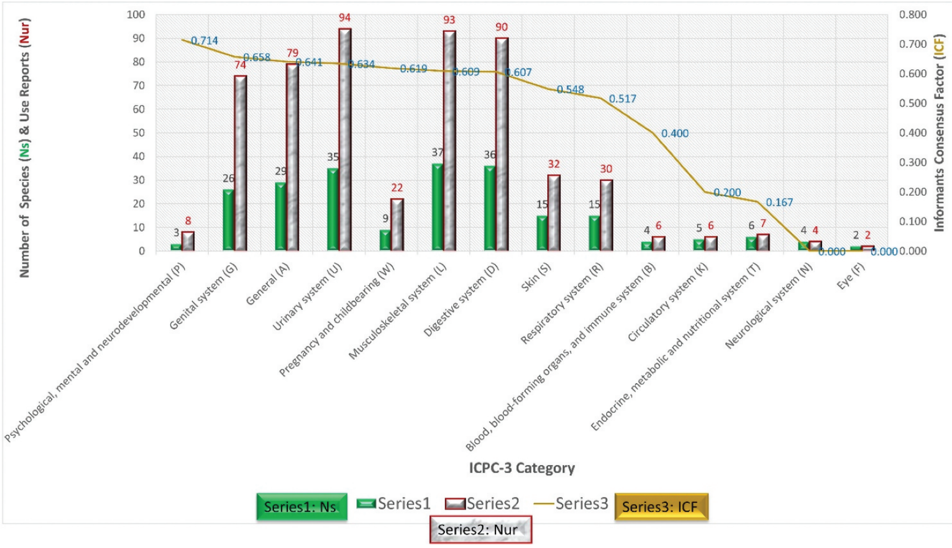


Figure 3. Informant consensus factor (ICF). International Classification of Primary Care (ICPC-3) categories recorded in the study area. N_{ur} denotes the total number of use reports in a use category and N_s denotes the number of species cited by informants in that use category.

Figure 4. Fidelity level (FL) & Relative frequency of citation (RFC) of ailments(s) prevented/treated in "*Osupetai*" by plants.

"*Ororobi*" had health conditions in the **A** and **R** ICPC-3 categories: **A** conditions were fever or malaria, and chest pain, while the **R** conditions were cough, influenza, and pneumonia or respiratory pain (Table S1). Some plants used to manage "*Osupetai*" or "*Olgila*" were also used against "*Ororobi*" (Figs. 6–9 & Table S1).

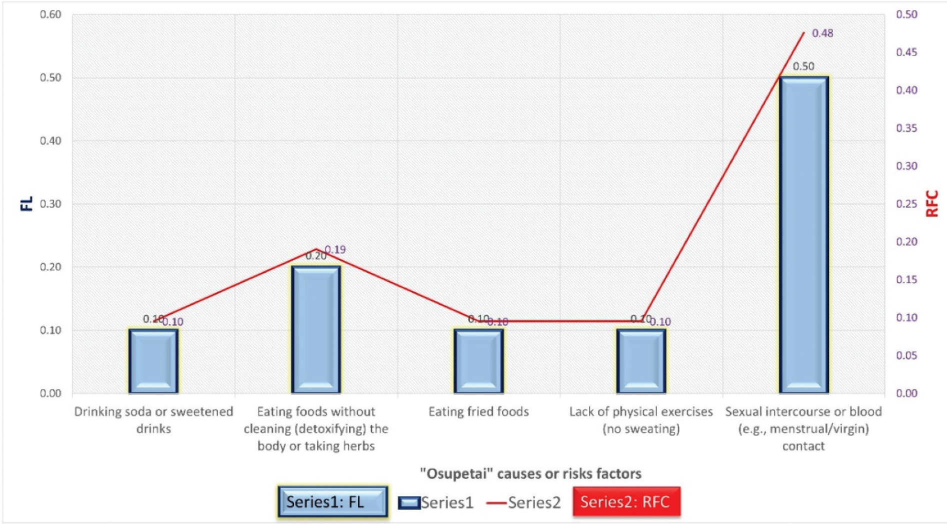


Figure 5. Fidelity level (FL) & Relative frequency of citation (RFC) of "*Osupetai*" risk factors.

Plants Used in the Maasai TFS and TM That Are Available in the Open Markets

The plant species (Table S2) observed in the open markets were cited in the interviews. For 67% of the plants, their voucher specimens were deposited at the National Herbarium, TPHPA. Parts of the observed plants were mainly sold for medicinal purposes. The medicinal uses of the observed plants were the same as were reported in the interviews, except *Acacia nilotica* which was sold for cleaning blood (S1 & S2). Some plant species were sold for "*Olgila*" (Table S1).

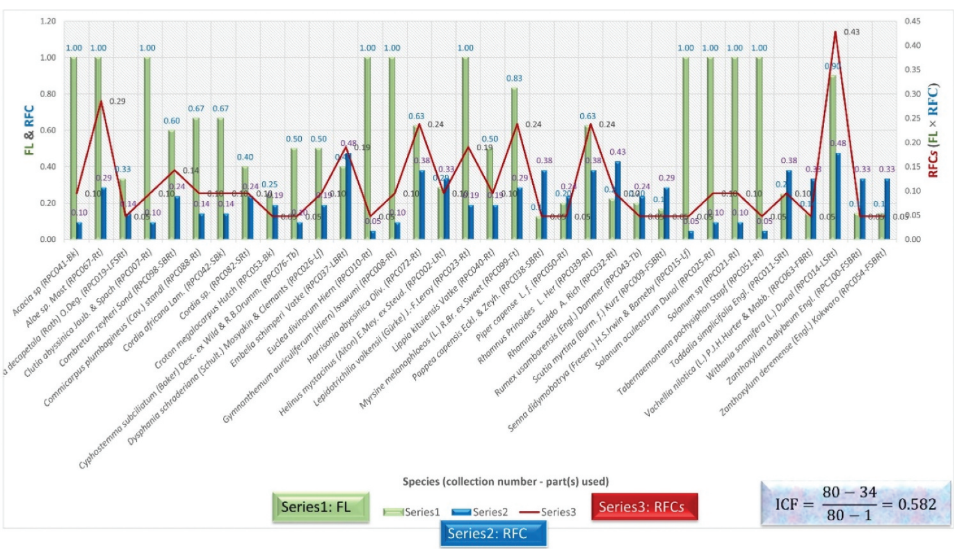


Figure 6. Fidelity level (FL) & Relative frequency of citation (RFC) and Specific Relative Frequency of Citation (RFC_s) of the plants used to manage the "*Osupetai*" health conditions.

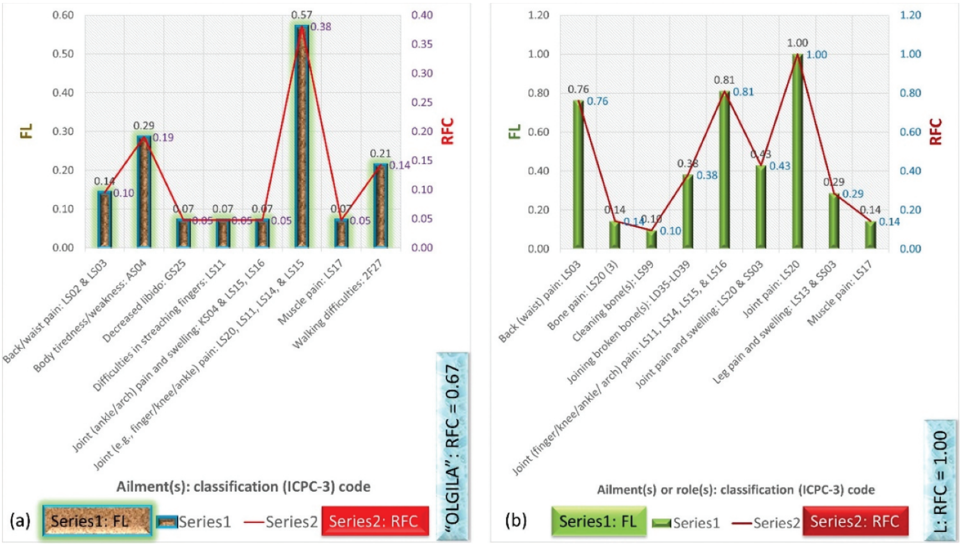


Figure 7. Fidelity level (FL) & Relative frequency of citation (RFC) of ailments(s) or health conditions in: (a) "*Olgila*" and (b) musculoskeletal (L) conditions.

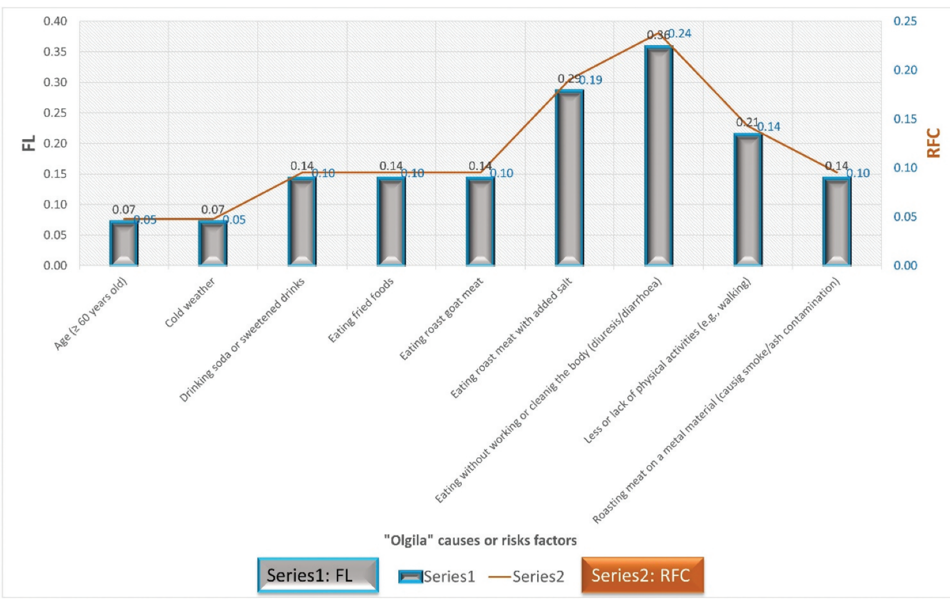


Figure 8. Fidelity level (FL) & Relative frequency of citation (RFC) "*Olgila*" risk factors.

Discussion

Diversity of Plants Used in the Study Area

The most represented families were, Fabaceae, followed by Euphorbiaceae, Rutaceae, Solanaceae, Boraginaceae, Lamiaceae, Malvaceae, Rhamnaceae, and

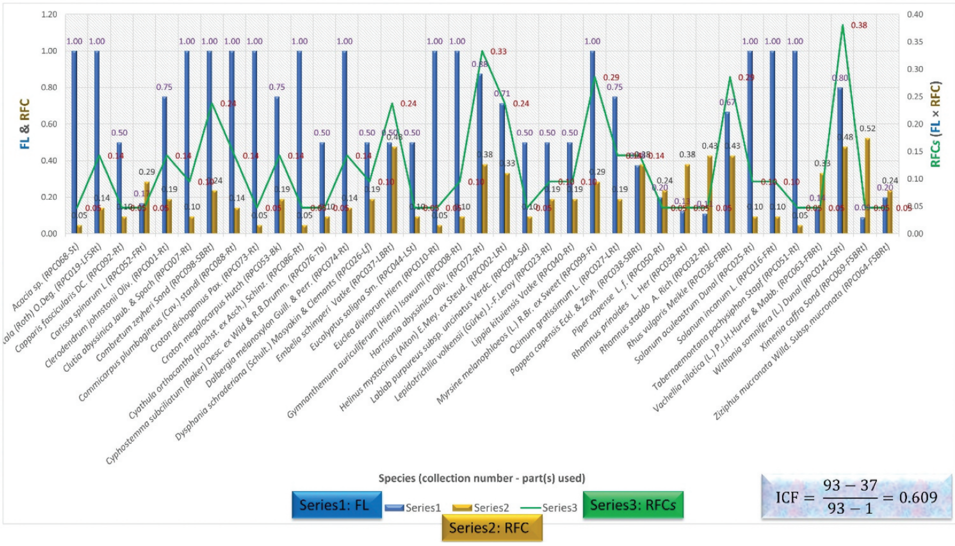


Figure 9. Fidelity level (FL) & Relative frequency of citation (RFC), and Specific Relative Frequency of Citation (RFC_s) of the plants used to manage the "*Olgila*" and musculoskeletal (L) health conditions.

Anacardiaceae which had 4–10 species each (Table S1). These families are among the topmost families of plants used in Tanzania.[8] Most plant species were sourced from the forest followed by savanna; the most common habit was tree as also reported for Ilkisonko Maasai of Kajiado County, Kenya.[1]

Benefits of Plants Used in Maasai TFS and TM

Plants used in traditional TFS and TM have a wide range of benefits in promoting health and well-being of people, who uphold their cultural practices.[1] The plants were used for medicines, food, or processing/storage (Fig. 2 & Table S1) which may contribute to the SDGs 2 and 3.[3]

Health Conditions and Disease Categories

The categories had ICF ranging from 0.00 to 0.714 while category **P** followed by **G** had the highest ICF (Fig. 3). Also, nine (9) categories had ICF >0.500 (Fig. 3). Higher ICF values suggest a systematic and well-defined selection of MPs in managing the health conditions including "*Osupetai*," "*Olgila*" and **L** (Figs. 6–9) with clear exchange of information among informants about their use.[29,31] Five (5) categories had ICF ˂ 0.500; Categories **N** and **F** had the lowest ICF of 0.00 (Fig. 3). Lower ICF values may suggest a random selection of MPs with no exchange of information among informants and a strong disagreement among informants due to different experiences and withholding information.[29,31]

Health Conditions Related to Gout and Managing MPs Thereof

Most of the "*Olgila*" health conditions particularly joint pain and swelling, difficulty in stretching fingers and walking, and decreased libido (Fig. 7a) relate to gout.[19] All the "*Olgila*" conditions except body weakness and reduced libido constitute conditions of the musculoskeletal system (Fig. 7). So "*Olgila*" is closely related to gout by sharing its musculoskeletal conditions with that of gout. Most risk factors of "*Olgila*" are similar to those of gout.[15,19]

"*Olgila*" (Fig. 7a) makes up a portion of "*Osupetai*" health conditions (Fig. 4). All risk factors of "*Osupetai*" except sexual intercourse or blood contact (Fig. 5) are similar to those of "*Olgila*" (Fig. 8). So, "*Olgila*" or gout shares health conditions and causes or risk factors with "*Osupetai*." But "*Osupetai*" has health conditions and risk factors more than those of "*Olgila*" (Figs. 4–8). Analysis of its conditions and risk factors showed that "*Osupetai*" constituted communicable and non-communicable diseases with various causes: bacteria, viruses, parasitic worms, arthritis and damage to tissues, weather changes, endocrine and neuron system disorders.[33]

"*Olgila*" was prevented or treated by various MPs (Fig. 9). Pain and swelling of fingers, knees and ankles were the most frequently cited conditions of the musculoskeletal system, **L** (Fig. 7). These conditions are among the symptoms of gout, a consequence of hyperuricemia, an elevated serum uric acid level.[16] Xanthine oxidoreductase (XOR) is converted from xanthine dehydrogenase (XDH) into its isoform xanthine oxidase (XO) under hypoxic/ischemic and inflammatory conditions[34,35] which can be irreversible if prolonged.[34] Increased activity of XO leads to hyperuricemia along with generations of reactive oxygen species (ROS): superoxide and hydrogen peroxide.[34] Increased levels of ROS can cause OS, while hyperuricemia can cause the precipitation of uric acid into monosodium urate crystals in tissues[34] triggering inflammation and pain in joint tissues.[36]

Withania somnifera followed by *Harrisonia abyssinica*, *Myrsine melanophloeos*, *Combretum zeyheri*, and *Embelia schimperi* were the most frequently used against "*Olgila*" and **L** conditions, particularly joint pain and swelling (Fig. 9 & Table S1). These species contain quercetin, alloptaeroxylin, embelin, procyanidin B3, and epicatechin[37–40] which are antioxidant and anti-inflammatory.[40,41] Flavonoids can prevent free radicals generation through chelating oxidative metals[41] and prevent inflammation by inhibiting cyclooxygenase enzymes[41] and quercetin can inhibit XO.[42] These biological activities of the phytochemicals lower the risk of developing hyperuricemia, gout, and GACs.[15,16] This explains why MPs are used in TM against inflammation.[1,43]

Gout or hyperuricemia may predispose to chronic kidney diseases CKD, cardiovascular disease, metabolic syndrome, diabetes mellitus, and erectile dysfunction[16,19] due to the prooxidative and/or proinflammatory roles of hyperuricemia.[16] Some of these MDs like hypertension, hyperlipidemia, and renal diseases can also predispose to hyperuricemia and/or gout.[19] So, MPs used against gout may lower the risk of MDs predisposed by gout.

Decreased libido, a known comorbidity associated with gout[19]was among the health conditions of gout, "*Olgila*" and "*Osupetai*" (Figs. 4–7a). Improving erection or libido was the most common role achieved by the MPs for promoting the health of the genital system, **G** (Table S1). *Pappea capensis* (Figs. 6–9) was among the species commonly used to improve erection/libido (Table S2), as reported earlier.[1,7] *Pappea capensis* contains zinc, vitamins C and E, and phenolic compounds like apigenin, kaempferol, and quercetin.[44,45] Zinc is a cofactor of antioxidant enzymes and insulin, while vitamins C and E prevent lipid peroxidation and inflammation.[44] Also, apigenin, kaempferol, and quercetin can inhibit XO.[42] Thus, *P. capensis* may prevent hyperuricemia, gout, and GACs like decreased libido.[16,19]

Inducing diuresis was among the most common approaches to cleaning the body, kidneys, and urine (Fig. 8 and Table S1). Diuresis, when induced by conventional diuretics, upset the bloodstream salt balance, worsening diabetes, and gout conditions.[46] *Withania somnifera* followed by *Rhamnus prinoides* were among the most common MPs used to induce diuresis with no side effects (Table S1). Furthermore, high potassium intake especially as alkaline salt provides an anti-urolithiasis effect which can dissolve kidney stones associated with uric acid,[47] which could support their use against gout symptoms, joint pain, and swelling (Figs. 6, 9, & Table S1).

Consistent with this study, *W. somnifera* was reported as a diuretic agent[48] and *W. somnifera* and *R. prinoides* were used against arthritis[1] due to the presence of flavonoids and saponins[49,50] which are also diuretics[51] and antioxidants.[42,49]

Gout is known to be associated with pregnancy.[21] Pregnant women with gout are at increased risk of having maternal complications[21] which are linked to OS associated with pregnancy.[52] Elevated level of reactive oxygen species (ROS) induces OS that leads to such pregnancy outcomes associated with gout.[52,53] Pregnancy is associated with hypoxic/ischemic and reperfusion conditions which convert XOR from xanthine dehydrogenase into its isoform XO.[52] The increased XO activity leads to hyperuricemia, along with the generation of ROS particularly superoxide free radical, thereby causing gout and preeclampsia associated with pregnancy.[52]

The OS promotes spontaneous abortion, especially before the end of the first trimester.[53] *Grewia villosa*, *Lannea schweinfurthii*, and *Ximenia caffra* were used against bleeding and abortion (Table S1). The presence of *p*-coumaric acid, catechin, kaempferol, quercetin, and ursolic acid with antioxidant, anti-inflammatory, and anti-hyperuricemia activities in these species[42,54–56] may support their use against the pregnancy outcomes associated with gout.[52] *Lannea schweinfurthii* and *Ximenia caffra* are used against anemia and abortion.[54,55] *Ximenia caffra* is also used against "*Olgila*" (Fig. 9).

Gout is also associated with digestive system (**D**) disorders. Components of **D** have a role in eliminating one-third of uric acid through the uricolysis process, thereby reducing the risk of gout.[57] Uricase is not present in human tissues.[57] Thus, any **D** disorder that impairs the excretion of uric acid, constitutes gout risk factors. Hyperchlorhydria, a high stomach acid, is one of the marked conditions in gout patients.[23] Hyperchlorhydria results from gastrinoma (Zollinger-Ellison syndrome), *Helicobacter pylori* infection, colorectal carcinoma, and diminished renal or hepatic function.[58,59] Moreover, it can lead to peptic ulcers, thickening of the gastrointestinal mucosa, delayed starch digestion, stomach bloating or flatulence, and liver enlargement, which leads to impaired renal uric acid excretion.[23,58,60] Thus, **D** disorders can lead to impaired excretion of uric acid in the intestinal tract and kidney increasing the risk of developing gout.

Constipation, indigestion, stomach bloating, and stomach ulcer, which are hyperchlorhydria symptoms, were among the **D** conditions managed by the MPs (Fig. 3 & Table S1). *Biancaea decapetala* was used against constipation, as also reported earlier.[61] *Biancaea decapetala* has antioxidants that support its use against gastrointestinal inflammations.[61] Likewise, the use of *W. somnifera* and *Ximenia caffra* against stomach ulcers is supported by their phytochemicals.[48,54] Resveratrol and quercetin promote gut commensal microbiota and keep gut epithelial barrier integrity[62] while kaempferol and quercetin have anticancer activity[63] which are also present in *Vachellia nilotica* (Figs. 6–9) with the synonym *Acacia nilotica* (Table S1). Thus, the biological activities of these compounds support the uses of the species against the hyperchlorhydria symptoms and against "*Olgila*" (Figs. 6, 9, & Table S1). *Ocimum gratissimum* is used elsewhere against rheumatism.[64]

Gout is also associated with some respiratory system (**R**) disorders.[22,65,66] A low level of serum uric acid is associated with higher rates of chronic obstructive pulmonary disease (COPD) and lung cancer in current smokers.[65] Hyperuricemia is among the high-risk factors of Acute Respiratory Distress Syndrome (ARDS) which is associated with **R** diseases including severe pneumonia, tuberculosis, or COVID-19[22,66]; malaria can also induce ARDS.[67] "*Ororobi*" health conditions fever, cough, chest pain, influenza, and pneumonia are the **R** diseases symptoms.[22,65,66] *Zanthoxylum chalybeum* and *Z. deremense* were among the most common species used against "*Ororobi*" and malaria (Table S1). These species contain phenolic compounds[68] which are antioxidants[34,41] and alkaloids that are antibacterial and antiplasmodic.[69]

Gout is associated with some circulatory system (**K**) disorders and through its pro-inflammatory and pro-oxidative effects can lead to **K** disorders and chronic kidney disease, CKD.[16,70] Blood pressure, swollen ankle, and blood vessel cleaning, signified by increased body strength and absence of heart tightness (Figs. 4, 7a, & Table S1) were among the **K** conditions managed by the MPs (Table S1). *Pappea capensis* and *Harrisonia abyssinica* were among the most common species used in cleaning blood vessels and swollen ankles respectively (Table S1). *P. capensis* can prevent hyperuricemia and OS,[42,45] lipid peroxidation and atherosclerosis.[16,44] Moreover, this species may contain potassium, which softens the endothelial cells by enhancing the release of nitric oxide (NO) thus, preventing the consequences associated with vascular stiffness.[71]

Asparagus setaceus, *Tragia ukambensis*, and *Hydnora abyssinica* were used against blood pressure (Table S1). *H. abyssinica* contains protocatechuic acid and catechin with antioxidant and anti-inflammatory properties[41,72] which may prevent OS and hypertension.[16] So, these MPs are not only important in managing the **K** disorders and CKD but, also in gout predisposed by or predisposing to the conditions,[16,18] consistent with reports (Figs. 6–9).

Gout is associated with diabetes mellitus, an endocrine, metabolic, and nutritional system (**T**) disorder,[18,73] which can cause OS-associated damage to beta cells, causing insulin deficiency.[73] Conversely, diabetes mellitus may lead to hyperuricemia and/or gout.[47,74,75] Diabetes was among the **T** conditions managed by *Asparagus setaceus*, *Tragia ukambensis*, and *Hydnora abyssinica* (Table S1) which are known to have antioxidant activity.[76]

Preventing or dissolving abdominal fat deposits was achieved by using *Ziziphus mucronata* and *Dombeya kirkii* (Table S2). *Z. mucronata* has phenolic compounds and alkaloids with antioxidant and antidiabetic properties, respectively.[77] Antidiabetic properties of the alkaloids involve inhibition of α-amylase and α-glucosidase, and increasing glucose uptake[77] which support the use of these species in lowering the risk for developing diabetes mellitus and consequently gout. Thus, *Z. mucronata* is also used against "*Olgila*" (Fig. 9).

Potential Roles of Plant on Causes or Risk Factors of Gout, "olgila" And GACs

This study documented the roles of plant on causes and risk factors for some diseases including gout, "*olgila*" and GACs (Figs. 5–8). Eating foods without working or cleaning the body, and/or taking herbs, followed by eating meat with added salt, and lack of physical activities were the most common risk factors of diseases including gout, "*olgila*" (Fig. 5–8). Consumption of purine-rich, high-fat, and high-carbohydrate foods poses the risk of developing hyperuricemia and gout, along with their inflammatory effects.[15,16] The purine-rich and high-fat foods were the most common in medicinal preparations and among food sources (Figs. 2–8) as noted earlier in the same area.[5] A low prevalence of diseases like gout and GACs is reported in IPs like the

Maasai community which integrate MPs in their TFS and TM.[1] This supports the claim that eating food without integrating herbs is a risk factor for developing such diseases (Figs. 5–8).

Eating roast meat with added salt was also a risk factor for developing gout (Fig. 8). This can be supported by the fact that meat can elevate serum uric acid levels precipitating with sodium to form monosodium urate crystals leading to gout and GACs.[16,78] Also, sodium intake may lead to hypertension, a risk factor for gout,[18] so MTPs did not add salt in roasting their meat.[5]

Other risk factors for developing gout were drinking soda or sweetened drinks and lack of exercise (Figs. 5–8). Physical activities increase insulin sensitivity, glucose uptake by the contracting skeletal muscles, and blood flow in the muscle cells promoting glucose transport into the cells.[74] Thus, physical activities lower the risks of developing MDs including diabetes mellitus, hypertension, CKD, and gout.[18,74] Physical activities like walking and agropastoral works carried out by >86% of the MTPs (Table S1) may explain the low prevalence MDs.[1]

Consumption of fried foods or meat roasted on metal containers or pots which enhances smoke and ash contamination on meat, were other risk factors for developing gout (Fig. 8). Food processing by baking, frying, grilling, roasting, and smoking are the main sources of polycyclic aromatic hydrocarbons (PAHs) in foods[79] and lead to high levels of protein oxidation and lipid-oxidation products.[80] Malondialdehyde (MDA) and 4-hydroxynonenal (HNE), the most common secondary products of lipid oxidation, can enhance further protein oxidation, leading to advanced glycation end products (AGEs) in processed meat.[80,81] AGEs and PAHs induce OS; but, PAHs are carcinogenic to humans.[82] The AGEs in humans can lead to inflammation, resulting in MDs including diabetes and its complications.[83,84]

Consuming fried foods and meat roasted on metal pots specially made of iron, can be a risk factor for developing MDs including gout. This can explain why MTPs always roast their meat using special sticks "*orjibet*" made from plants like *Combretum zeyheri* instead of metal.[5] *C. zeyheri* is also used in preparing "*Olchani-imotori*," a plants' decoction mixed with meat broth or stock (Fig. 2) that is always consumed along with cooked foods.[5] *C. zeyheri* has phytochemicals with antioxidant properties.[39] Flavonoids can chelate the iron while processing or consuming meat, lowering the risk of the MDs associated with processed meat.[80]

Preparation, Doses, and Route of Delivery

The plant decoction in meat broth or stock, "*Olchani-imotori*" was the most common preparation (Fig. 2). Likewise, "*Olchani-imotori*" was more often used along with roast or cooked meat for preventive or therapeutic roles against diseases (Table S1) as also reported elsewhere.[5]

The most common plant part used was the root as also reported earlier (1). The dosages of preparations varied among informants as they were given based on age, sex, and health conditions. For instance, *Embelia schimperi* was not used by pre-menopausal women as it induced excessive menstrual flow and abortion (Table S1).

Conservation Status

Most plants were native and harvested from the wild, and some were sold in open markets (Fig. 1 & Table S2). The dependency on MPs for treating diseases and overuse by vending them in the open markets threatens the environment and plant diversity.[7,29] For instance, *Dalbergia melanoxylon* and *Zanthoxylum deremense* were in the near threatened (NT) and vulnerable (VU) categories of the IUCN red list respectively (Table S1). But, most of the plant species in the IUCN red list are in the LC category (Table S1). The local conservation practices of the plant use need to be aligned with SDG 13: Climate Action and SDG 15: Life on land.[9]

This study did not establish the nature, content, bioactivity, or safety of phytochemicals, nutrients, or minerals in plant used against gout ("*olgila*"), GACs, and disease risk factors by MTPs in their TFS and TM. There may also be potential bias in data collection caused by participants who lost their cultural practices in TFS and TM or may be unevenly geographically distributed in the target study area. Other potential barriers may include reluctance to share information, participate in the study by the participants, or limited time for participation.

Acknowledgments

The author and co-authors extend the deepest gratefulness to the community of Monduli district, Arusha particularly the one living in Engalaoni, Imbibia, Lossimingori, Lemiyoni, Makuyuni juu, Mlimani, and Zaburi villages, as well as MTPs who participated deliberately in the present study. The local authorities are exceptionally cherished for the friendly support given to us during the fieldwork in the study area. We also thank the staff of the National Herbarium (TPHPA) for assisting us in herbarium work. Special appreciation goes to Gabriel S Laizer (Field botanist) and his team members, Dr. Neduvoto Piniel Mollel (Head of Division, National Herbarium, TPHPA), John Elia Ntandu (TPHPA researcher), and Diana Mbaruku (TPHPA herbarium database Logger), for their extrovert assistance during the identification and validation of the specimens. Also, special thanks go to the Tanzania Forest Service of the Monduli District (*TFS-Monduli*), Arusha, for their prodigious support and approval to include some of the areas under their authority in this study.

Disclosure Statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by the Tanzania Ministry of Education Science and Technology (MoEST).

ORCID

Richard P. Clement http://orcid.org/0000-0002-4800-0558
Joseph Runyogote http://orcid.org/0000-0003-4636-0127
Jofrey Raymond http://orcid.org/0000-0002-3500-2183
Musa N. Chacha http://orcid.org/0000-0001-5470-0297

Data Availability Statement

The authors confirm that the data supporting the findings of this study are available within the article [and/or] its supplementary materials.

Ethical approval and consent to participate

This study was performed by considering Bennett's Golden Rule for Ethnobotany Field Work [28]. Also, an official approval and support letter was provided by the Nelson Mandela African Institution of Science and Technology (NM-AIST) administration. The study participants were informed about the benefits of taking part in the present study. To obtain their consent, a brief discussion was made with the MTPs, and the aim of the study was clarified so that they would be clear about the intention of documenting the flora and knowledge thereof used in TFS and TM for academic use with no commercialization being involved. It was also made clear that the usual benefits they receive by practicing their TFS and TM will not be affected by giving full information about the flora used in TFS and TM. Verbal consent was obtained from the study participants before the commencement of the study. The costs of travel and time spent were remunerated with modest payments.

Consent for Publication

All authors have read the manuscript and agreed for publication.

Author's Contributions

RPC: Conceptualization, methodology, investigation, writing-original draft and editing. **JR**[c], **JR**[a], and **MNC**: reviewing, editing, and Supervision.

References

[1] Kimondo, J. W. *An Evaluation of Antioxidant and Anti-Inflammatory Effects of Natural Foods and Medicinal Plants of the Ilkisonko Maasai Community, Kenya* (Doctoral dissertation). University of Nairobi, 2020.

[2] Kuhnlein, H. V. Food System Sustainability for Health and Well-Being of Indigenous Peoples. *Public. Health. Nutr.* 2014, *18*(13), 2415–2424. DOI: 10.1017/S1368980014002961.

[3] United Nations. The 2030 Agenda for Sustainable Development's 17 Sustainable Development Goals (SDGs). 2015; pp 10–15. https://sustainabledevelopment.un.org/content/documents/21252030. Agenda for Sustainable Development web.pdf.

[4] Roulette, C. J.; Njau, E. F. A.; Quinlan, M. B.; Quinlan, R. J.; Call, D. R. Medicinal Foods and Beverages Among Maasai Agro-Pastoralists in Northern Tanzania. *J. Ethnopharmacol.* 2018, *216*, 191–202. DOI: 10.1016/j.jep.2018.01.022.

[5] Clement, R. P.; Runyogote, J.; Raymond, J.; Chacha, M. N. Ethnobiological Survey to Determine the Link Between Health Benefits and Qualities of Maasai Traditional Food System in Monduli, Arusha, Tanzania. *Agroecol. Sustain. Food. Syst.* [Internet]. 2023, *47* (8), 1077–1124. 10.1080/21683565.2023.2229786.

[6] Amjad, M. S.; Zahoor, U.; Bussmann, R. W.; Altaf, M.; Gardazi, S. M. H.; Abbasi, A. M. Ethnobotanical Survey of the Medicinal Plant of Harighal, Azad Jammu & Kashmir, Pakistan. *J. Ethnobiol. Ethnomed.* 2020, *16*(1), 1–28. DOI: 10.1186/s13002-020-00417-w.

[7] Makule, E. *Ethnopharmacological Survey and Phytochemical Investigation of Maasai Traditional Medicinal Plants from North-Eastern Tanzania Dissertation* (Doctoral dissertation), 2018.

[8] Hilonga, S.; Otieno, J. N.; Ghorbani, A.; Pereus, D.; Kocyan, A.; de Boer, H. Trade of Wild-Harvested Medicinal Plant Species in Local Markets of Tanzania and Its Implications for Conservation. *South African J. Bot.* [Internet]. 2018, *122*, 214–224. DOI: 10.1016/j.sajb.2018.08.012.

[9] Carpentier, C. L.; Braun, H. Agenda 2030 for Sustainable Development: A Powerful Global Framework. *J. Int. Counc. Small. Businesssdg.* 2020, *1*(1), 14–23. DOI: 10.1080/26437015.2020.1714356.

[10] Being Maasai, H. D. *Becoming Indigenous: Postcolonial Politics in a Neoliberal World*; Indiana University Press: Bloomington, Indiana 47404-3797 USA, 2011.

[11] Lemke, S.; Delormier, T. Indigenous Peoples' Food Systems, Nutrition, and Gender: Conceptual and Methodological Considerations. *Matern. Child Nutr.* 2017, *13*(S3), e12499. DOI: 10.1111/mcn.12499.

[12] Raschke, V.; Cheema, B. Colonisation, the New World Order, and the Eradication of Traditional Food Habits in East Africa: Historical Perspective on the Nutrition Transition. *Public. Health. Nutr.* 2008, *11*(7), 662–674. DOI: 10.1017/S1368980007001140.

[13] Gliessman, S. R.; EW, E., editor *Agroecology: The Ecology of Sustainable Food Systems*, 3rd ed.; CRC Press Taylor & Francis Group: Boca Raton London New York, 2015.

[14] Kuhnlein, H. V. Food System Sustainability for Health and Well-Being of Indigenous Peoples. *Public. Health. Nutr.* 2015, *18*(13), 2415–2424. DOI: 10.1017/S1368980014002961.

[15] Li, C.; Jiang, S.; Liu, H. Dietary Regulation of Oxidative Stress in Chronic Metabolic Diseases. *Foods* 2021, *10*(8), 1854. DOI: 10.3390/foods10081854.

[16] Gherghina, M. E.; Peride, I.; Tiglis, M.; Neagu, T. P.; Niculae, A.; Checherita, I. A. Uric Acid and Oxidative Stress—Relationship with Cardiovascular, Metabolic, and Renal Impairment. *Int. J. Mol. Sci.* 2022, *23*(6), 3188. DOI: 10.3390/ijms23063188.

[17] Mody, G. M. Rheumatology in Africa—Challenges and Opportunities. *Arthritis Res. Ther* 2017, *19*(1), 1–3. DOI: 10.1186/s13075-017-1259-3.
[18] Ragab, G.; Elshahaly, M.; Bardin, T. Gout: An Old Disease in New Perspective – a Review. *J. Adv. Res.* [Internet]. 2017, *8*(5), 495–511. DOI: 10.1016/j.jare.2017.04.008.
[19] Dehlin, M.; Jacobsson, L.; Roddy, E. Global Epidemiology of Gout: Prevalence, Incidence, Treatment Patterns and Risk Factors. *Nat. Rev. Rheumatol.* [Internet]. 2020, *16*(7), 380–390. DOI: 10.1038/s41584-020-0441-1.
[20] Stack, A.; Manolis, A. J.; Ritz, E. Detrimental Role of Hyperuricemia on the Cardio-Reno-Vascular System. *Curr. Med. Res. Opin*. 2015, *31*(sup2), 21–26. DOI: 10.1185/03007995.2015.1087984.
[21] Horta-Baas, G.; Hernández-Cabrera, M. F.; Vergara-Sánchez, I.; Romero-Figueroa, S. Gout and Pregnancy: A Report of a New Case and Systematic Review *Rev. Colomb. Reumatol.* 2017, *24*(4), 219–229.
[22] Peng, H.; Wu, X.; Xiong, S.; Li, C.; Zhong, R.; He, J.; Liang, W. Gout and Susceptibility and Severity of COVID-19: A Bidirectional Mendelian Randomization Analysis. *J. Infect.* [Internet]. 2022, *85*(3), e59–61. 10.1016/j.jinf.2022.05.042.
[23] Stockton, C. G. Gastro-Intestinal and Hepatic Relations of Gout. *J. Am. Med. Assoc.* [Internet]. 1897, *29*(5), 222–223. http://jama.jamanetwork.com/ .
[24] MacGregor, G. A.; He, F. J. Fortnightly Review: Beneficial Effects of Potassium. *BMJ* 2001, *323*(7311), 497–501. DOI: 10.1136/bmj.323.7311.497.
[25] Tanzania, National Bureau of Statistics. Population and Housing Census: population distribution by administrative areas. *Ministry of Finance, Dar es Salaam*, 2012.
[26] Khamis, A. G.; Senkoro, M.; Mwanri, A. W.; Kreppel, K.; Mfinanga, S. G.; Bonfoh, B., Kwesigabo G. Prevalence and Determinants of Hypertension Among Pastoralists in Monduli District, Arusha Region in Tanzania: A Cross-Sectional Study. *Arch. Public. Heal.* 2020, *78*(1), 1–12.
[27] Quinlan, R. J.; Rumas, I.; Naisikye, G.; Quinlan, M. B.; Yoder, J. Searching for Symbolic Value of Cattle: Tropical Livestock Units, Market Price, and Cultural Value of Maasai Livestock. *Ethno. Biol. Lett.* 2016, *7*(1), 76–86. DOI: 10.14237/ebl.7.1.2016.621.
[28] McClatchey, W.; Gollin, L. X. An Ethnobotany Research Training Workshop in Madagascar. *Ethnobot. Res. Appl.* 2005, *3*, 309–328. DOI: 10.17348/era.3.0.309-328.
[29] Tuasha, N.; Petros, B.; Asfaw, Z. Medicinal Plants Used by Traditional Healers to Treat Malignancies and Other Human Ailments in Dalle District, Sidama Zone, Ethiopia. *J. Ethnobiol. Ethnomed.* 2018, *14*(1), 15. DOI: 10.1186/s13002-018-0213-z.
[30] FTEA (1952-2012). Plant of Tropical East Africa. In *Royal Botanic Garden, Kew*; Polhill, D., Roger P., Eds. London, 2012.
[31] Issa, T. O.; Mohamed, Y. S.; Yagi, S.; Ahmed, R. H.; Najeeb, T. M.; Makhawi, A. M., Khider TO. Ethnobotanical Investigation on Medicinal Plants in Algoz Area South Kordofan. *Sudan. J. Ethnobiol. Ethnomed.* 2018, *14*(1), 1–22.
[32] Cook, F. E. *Economic Botany Data Collection Standard*; Royal Botanic Gardens (Kew): Kew, 1995.
[33] Clement, R. P.; Raymond, J.; Chacha, M. N. *Ethnobotanical Survey of Plant Used in the Maasai Food System and Traditional Medicine Against Gout-Related and Other Human Ailments in Monduli*; Arusha, Tanzania, 2021. DOI:10.21203/rs.3.rs-838942/v1.
[34] Bortolotti, M.; Polito, L.; Battelli, M. G.; Bolognesi, A. Xanthine Oxidoreductase: One Enzyme for Multiple Physiological Tasks. *Redox Biol.* [Internet]. 2021, *41*, 101882. 10.1016/j.redox.2021.101882.
[35] David, B.-O.; Carrick, M. M.; Mains, C. W.; Rael, L. T.; Slone, D.; Brody, E. N. Sepsis, Oxidative Stress, and Hypoxia: Are There Clues to Better Treatment? *Redox Rep.* 2015, *20*(5), 193–197. DOI: 10.1179/1351000215Y.0000000005.

[36] Allegrini, S.; M, G.-G.; Pesi, R.; Camici, M.; Tozzi, M. G. The Good, the Bad and the New About Uric Acid in Cancer. *Canc. (Basel)* 2022, *14*(19), 4959. DOI: 10.3390/cancers14194959.

[37] Akram, M.; Usmanghani, K.; Ahmed, I.; Azhar, I.; Hamid, A. In vitro Xanthine Oxidase Inhibitory and in vivo Hypouricemic Activity of Herbal Coded Formulation (Gouticin). *Pak. J. Pharm. Sci.* 2014, *27*(3), 541–550.

[38] Masila, V. M. *Phytochemical Investigation of Harrisonia Abyssinica and Thespesia Garckeana for Antiplasmodial and Antimicrobial Compounds* (Doctoral dissertation) University of Nairobi, 2014.

[39] Fyhrquist, P.; Salih, E. Y. A.; Helenius, S.; Laakso, I.; Julkunen-Tiitto, R. HPLC-DAD and UHPLC/QTOF-MS Analysis of Polyphenols in Extracts of the African Species Combretum Padoides, C. Zeyheri and C. Psidioides Related to Their Antimycobacterial Activity. *Antibiotics*. 2020, *9*(8), 459. DOI: 10.3390/antibiotics9080459.

[40] Caruso, F.; Rossi, M.; Kaur, S.; Garcia-Villar, E.; Molasky, N.; Belli, S.; Sitek, J. D.; Gionfra, F.; Pedersen, J. Z.; Incerpi, S., et al. Antioxidant Properties of Embelin in Cell Culture. Electrochemistry and Theoretical Mechanism of Scavenging. Potential Scavenging of Superoxide Radical Through the Membrane Cell. *Antioxidants* 2020, *9* (5), 382. DOI: 10.3390/antiox9050382.

[41] Amarowicz, R.; Pegg, R. B. Natural Antioxidants of Plant Origin [Internet]. In Advances in Food and Nutrition Research, 1st ed.; Elsevier Inc., 2019; Vol. 90, pp. 1–81. DOI: 10.1016/bs.afnr.2019.02.011.

[42] Ayyappan, P.; Nampoothiri, S. V. Bioactive Natural Products As Potent Inhibitors of Xanthine Oxidase [Internet. In Studies in Natural Products Chemistry, 1st ed.; Elsevier Inc., 2020; Vol. 64, pp. 391–416. DOI: 10.1016/B978-0-12-817903-1.00013-9.

[43] Kougan, G. B.; Tabopda, T.; Kuete, V.; Simple Phenols, V. R. Simple phenols, phenolic acids, and related esters from the medicinal plants of Africa. In Medicinal plant research in Africa; Elsevier, 2013; pp 225–249. DOI: 10.1016/B978-0-12-405927-6.00006-0.

[44] Karau, G. M.; Njagi, E. N. M.; Machocho, A. K.; Wangai, L. N. Phytonutrient, Mineral Composition and in vitro Antioxidant Activity of Leaf and Stem Bark Powders of Pappea Capensis (L.). *Pakistan J. Nutr.* 2012, *11*(2), 123–132. DOI: 10.3923/pjn.2012.123.132.

[45] Muruthi, C. W.; Ngugi, M. P.; Runo, S. M.; Mwitari, P. G. In vitro Antioxidant Activities of Carissa Edulis ((Forssk) Vahl) and Pappea Capensis (Eckyl. & Zeyh) Extracts. *Heliyon* [Internet]. 2023, *9*(1), e12965. 10.1016/j.heliyon.2023.e12965.

[46] Hedaoo, S. A.; Bodhankar, M. M. Advantages of Natural Diuretics Over Synthetic. *World J. Pharm. Pharm. Sci.* 2019, *8*(3), 310–327.

[47] Barbera, M.; Tsirgiotis, A.; Barbera, M.; Paola, Q. The Importance of Potassium Citrate and Potassium Bicarbonate in the Treatment of Uric Acid Renal Stones. *Arch. Ital. di. Urol. E. Androl.* 2016, *88*(4), 341–342. DOI: 10.4081/aiua.2016.4.341.

[48] Gaurav, H.; Yadav, D.; Maurya, A.; Yadav, H.; Yadav, R.; Shukla, A. C., Sharma M, Gupta VK, Palazon J. Biodiversity, Biochemical Profiling, and Pharmaco-Commercial Applications of Withania Somnifera: A Review. *Molecules* 2023, *28*(3), 1208. DOI: 10.3390/molecules28031208.

[49] Saleem, S.; Muhammad, G.; Hussain, M. A.; Altaf, M.; Bukhari, S. N. A. Withania Somnifera L.: Insights into the Phytochemical Profile, Therapeutic Potential, Clinical Trials, and Future Prospective. IRAN J. BASIC MED. SCI. 2020, *23*(12), 1501. DOI: 10.22038/IJBMS.2020.44254.10378.

[50] Chen, G.-L.; Mutie, F. M.; Xu, Y.-B.; Saleri, F. D.; Hu, G.-W.; Guo, M.-Q. Antioxidant, Anti-Inflammatory Activities and Polyphenol Profile of Rhamnus Prinoides. *Pharmaceuticals*. 2020, *13*(4), 55. DOI: 10.3390/ph13040055.

[51] Aswini, E. V.; Vivek, D.; Swathilakshmi, S. Role of Phytochemicals in Diuresis Management. *World J Pharm. Res.* 2020, *9*(13), 551–562.
[52] Di Fabrizio, C.; Giorgione, V.; Khalil, A.; Murdoch, C. E. Antioxidants in Pregnancy: Do We Really Need More Trials? *Antioxidants*. 2022, *11*(5), 812. DOI: 10.3390/antiox11050812.
[53] Al-Gubory, K. H.; Fowler, P. A.; Garrel, C. The Roles of Cellular Reactive Oxygen Species, Oxidative Stress and Antioxidants in Pregnancy Outcomes. *Int. J. Biochem. Cell Biol*. 2010, *42*(10), 1634–1650. DOI: 10.1016/j.biocel.2010.06.001.
[54] Maroyi, A. Ximenia Caffra Sond. (Ximeniaceae) in Sub-Saharan Africa: A Synthesis and Review of Its Medicinal Potential. *J. Ethnopharmacol.* [Internet]. 2016, *184*, 81–100. 10.1016/j.jep.2016.02.052.
[55] Maroyi, A. Review of Ethnomedicinal, Phytochemical and Pharmacological Properties of Lannea Schweinfurthii (Engl.) Engl. *Molecules*. 2019, *24*(4), 732. DOI: 10.3390/molecules24040732.
[56] Sanvitha, K.; Rani, M. S.; Mohan, G. K. An Overview on Wild Plant Grewia Villosa (Malvaceae). *J. Pharmacogn. Phytochem.* 2022, *11*(6), 134–138.
[57] Sorensen, L. B. Role of the Intestinal Tract in the Elimination of Uric Acid. *Arthritis. Rheum. Off. J. Am. Coll. Rheumatol* 1965, *8*(4), 694–706. DOI: 10.1002/art.1780080429.
[58] Shulkes, A.; Baldwin, G. S. Gastrin. In Handbook of Biologically Active Peptides; Academic Press, 2013; pp 1219–1226. DOI: 10.1016/B978-0-12-385095-9.00165-2.
[59] Alter, D. N. Clinical Chemistry of the Gastrointestinal Disorders. In Contemporary Practice in Clinical Chemistry; Academic Press, 2020; pp. 561–572. DOI: 10.1016/B978-0-12-815499-1.00032-6.
[60] Zhang, B.; Zeng, X. Tophaceous Gout in a Female Premenopausal Patient with an Unexpected Diagnosis of Glycogen Storage Disease Type Ia: A Case Report and Literature Review. *Clin. Rheumatol.* [Internet]. 2016, *35*(11), 2851–2856. 10.1007/s10067-016-3290-1.
[61] Bhadoriya, U.; Sharma, P.; Solanki, S. S. In vitro Free Radical Scavenging Activity of Gallic Acid Isolated from Caesalpinia Decapetala Wood. *Asian. Pac. J. Trop. Dis.* [Internet]. 2012, *2*, S833–6. 10.1016/S2222-1808(12)60274-6.
[62] García-Montero, C.; Fraile-Martínez, O.; Gómez-Lahoz, A. M.; Pekarek, L.; Castellanos, A. J.; Noguerales-Fraguas, F.; Coca, S.; Guijarro, L. G.; García-Honduvilla, N.; Asúnsolo, A., et al. Nutritional Components in Western Diet versus Mediterranean Diet at the Gut Microbiota–Immune System Interplay. Implications for Health and Disease. *Nutrients* 2021, *13*(2), 699. DOI: 10.3390/nu13020699.
[63] Al-Nour, M. Y.; Ibrahim, M. M.; Elsaman, T. Ellagic Acid, Kaempferol, and Quercetin from Acacia Nilotica: Promising Combined Drug with Multiple Mechanisms of Action. *Curr. Pharmacol. Rep*. 2019, *5*(4), 255–280. DOI: 10.1007/s40495-019-00181-w.
[64] Ajayi, A. M.; Ologe, M. O.; Ben-Azu, B.; Okhale, S. E.; Adzu, B.; Ademowo, O. O. G. L. Ocimum Gratissimum Linn. Leaf Extract Inhibits Free Radical Generation and Suppressed Inflammation in Carrageenan-Induced Inflammation Models in Rats. *J. Basic Clin. Physiol. Pharmacol.* 2017, *28*(6), 531–541. DOI: 10.1515/jbcpp-2016-0096.
[65] Horsfall, L. J.; Nazareth, I.; Petersen, I. Serum Uric Acid and the Risk of Respiratory Disease: A Population-Based Cohort Study. *Thorax*. 2014, *69*(11), 1021–1026. DOI: 10.1136/thoraxjnl-2014-205271.
[66] Wang, W.; Zhou, Y.; Su, Z.; Luo, L.; Zhao, L. Acute Respiratory Distress Syndrome in One Patient with Gout Complicated by Severe Pulmonary Tuberculosis: Report of One Case and Literature Review. *J. Thorac. Dis.* 2013, *5*(2), E50.

[67] Taylor, W. R. J.; Hanson, J.; Turner, G. D. H.; White, N. J.; Dondorp, A. M. Respiratory Manifestations of Malaria. *Chest*. 2012, *142*(2), 492–505. DOI: 10.1378/chest.11-2655.

[68] Ochieng, C. O.; Nyongesa, D. W.; Yamo, K. O.; Onyango, J. O.; Langat, M. K.; Manguro, L. A. O. α-Amylase and α-Glucosidase Inhibitors from Zanthoxylum Chalybeum Engl. Root Bark. *Fitoterapia* 2020, *146*, 104719. DOI: 10.1016/j.fitote.2020.104719.

[69] Mbunde, M. V. N.; Innocent, E.; Mabiki, F.; Andersson, P. G. Ethnobotanical Survey and Toxicity Evaluation of Medicinal Plants Used for Fungal Remedy in the Southern Highlands of Tanzania. *J. Intercult. Ethnopharmacol.* 2017, *6*(1), 84. DOI: 10.5455/jice.20161222103956.

[70] Ramirez-Sandoval, J. C.; Sanchez-Lozada, L. G.; Madero, M. Uric Acid, Vascular Stiffness, and Chronic Kidney Disease: Is There a Link? *Blood. Purif.* 2017, *43*(1–3), 189–195. DOI: 10.1159/000452726.

[71] Oberleithner, H.; Callies, C.; Kusche-Vihrog, K.; Schillers, H.; Shahin, V.; Riethmuller, C., Macgregor, GA, De Wardener HE. Potassium Softens Vascular Endothelium and Increases Nitric Oxide Release. *Proc. Natl. Acad. Sci. U. S. A* 2009, *106*(8), 2829–2834. DOI: 10.1073/pnas.0813069106.

[72] Al-Fatimi, M.; Ali, N. A. A.; Kilian, N.; Franke, K.; Arnold, N.; Kuhnt, C., Schmidt J, Lindequist U. Ethnobotany, Chemical Constituents and Biological Activities of the Flowers of Hydnora Abyssinica A.Br. *(Hydnoraceae). Pharm.* 2016, *71*(4), 222–226.

[73] Lv, Q.; Meng, X. F.; He, F. F.; Chen, S.; Su, H.; Xiong, J.; Gao, P.; Tian, X.-J.; Liu, J.-S.; Zhu, Z.-H., et al. High Serum Uric Acid and Increased Risk of Type 2 Diabetes: A Systemic Review and Meta-Analysis of Prospective Cohort Studies. *PLOS One*. 2013, *8*(2), e56864.

[74] Oguntibeju, O. O. Type 2 Diabetes Mellitus, Oxidative Stress and Inflammation: Examining the Links. *Int. J. Physiol. Pathophysiol. Pharmacol.* [Internet]. 2019, *11*(3), 45. http://www.ncbi.nlm.nih.gov/pubmed/31333808%0Ahttp://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC6628012.

[75] Dhatariya, K. K.; Glaser, N. S.; Codner, E.; Umpierrez, G. E. Diabetic ketoacidosis. *Nat. Rev. Dis. Prim.* 2020, *6*(1), 40. DOI: 10.1038/s41572-020-0165-1.

[76] Asmat, U.; Abad, K.; Ismail, K. Diabetes Mellitus and Oxidative Stress—A Concise Review. *Saudi Pharm. J.* [Internet]. 2016, *24*(5), 547–553. 10.1016/j.jsps.2015.03.013.

[77] Costa Mousinho Nmh, D.; Van Tonder, J. J.; Steenkamp, V. In vitro Anti-Diabetic Activity of Sclerocarya Birrea and Ziziphus Mucronata. *Nat. Prod. Commun*. 2013, *8*(9), 1279–1284.

[78] So, A. K.; Martinon, F. Inflammation in Gout: Mechanisms and Therapeutic Targets. *Nat. Rev. Rheumatol.* [Internet]. 2017, *13*(11), 639–647. 10.1038/nrrheum.2017.155.

[79] Pang, Y. H.; Sun, M.; Shen, X. F.; Yue, Q.; Ma, T. T.; Yang, C. Determination of Benzo[a] pyrene in Roast Meat by in situ Growth of Covalent Organic Framework on Titanium Wire for Solid-Phase Microextraction Coupled with GC-FID. *Food Anal. Methods*. 2020, *13*(10), 1938–1946. DOI: 10.1007/s12161-020-01812-5.

[80] Hu, L.; Ren, S.; Shen, Q.; Chen, J.; Ye, X.; Ling, J. Proteomic Study of the Effect of Different Cooking Methods on Protein Oxidation in Fish Fillets. *R.S.C. Adv*. 2017, *7*(44), 27496–27505. DOI: 10.1039/C7RA03408C.

[81] Zhu, Z.; Bassey, A. P.; Huang, M.; Khan, I. A. The Effect of Protein Oxidation on the Formation of Advanced Glycation End Products After Chicken Myofibrillar Protein Glycation. *Food Sci. Hum. Wellness* [Internet]. 2023, *12*(5), 1571–1579. 10.1016/j.fshw.2023.02.013.

[82] Barreira, L. P. V. A. Polycyclic Aromatic Hydrocarbons and Oxidative Stress Markers in the Clam Ruditapes Decussatus from the Ria Formosa (Portugal) [Internet].

Universidade do Algarve (Portugal), 2007. https://sapientia.ualg.pt/bitstream/10400.1/692/1/L. Barreira - Tese Definitiva com correcções.pdf.
[83] Heidari, F.; Rabizadeh, S.; Rajab, A.; Heidari, F.; Mouodi, M.; Mirmiranpour, H., Esteghamati A, Nakhjavani M. Advanced Glycation End-Products and Advanced Oxidation Protein Products Levels Are Correlates of Duration of Type 2 Diabetes. *Life. sci.* [Internet]. 2020, *260*, 118422. 10.1016/j.lfs.2020.118422.
[84] Kim, Y.; Keogh, J.; Clifton, P. A Review of Potential Metabolic Etiologies of the Observed Association Between Red Meat Consumption and Development of Type 2 Diabetes Mellitus. *Metabolism* [Internet]. 2015, *64*(7), 768–779. 10.1016/j.metabol.2015.03.008.