Ethno-functional food studies of non-commercial fruits used by Tribals of southern Rajasthan India

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Abstract
Since time immemorial fruits form a suggestive major protective, restorative and curative element in various maladies. The present study aimed to document these functional fruits for their pharmacological properties. Ethno-medicinal survey of southern Rajasthan reveals usage of 50 fruit plants among which fifteen fruits are used in diabetes, eleven in digestive disorders and four in respiratory ailments. None of the informants depicted the usage of fruits or its components for immune system or ailments related to neurological complications. Grains and seeds were either utilized as boiled rice or were used for making bread.

Keywords: Functional foods, traditional fruits, diabetes, southern Rajasthan

Introduction
Food and health are intervened and their connections have been established since the inception of human civilization. The evolution of food processing has quenched the taste buds but has enormously declined its quality [1]. Thermo-labile components of the foods are destroyed during cooking process and hence the dieticians recommend fruits and salads in the dietary health management strategies. Fruits are the good sources of simple sugars, fibers, vitamins, minerals and water. Their consumption as raw adds more functional quality as thermo-sensitive components are retained in their native forms [2, 3]. Despite commercial fruit markets and plazas, the aboriginals still rely on their non-commercial local foods among which fruits occupy significant place [4]. These peoples are aware of their functional properties and therefore apply as needed among various maladies. Documentation and further application of such inherent in modern scenario ignored fruits will help in managing pharmacopeia.

As per the 2011 census, the Scheduled Tribe (ST) population of Rajasthan state is 9,238,534 constituting 8.9 percent of the total ST population of India. Tribes in Rajasthan are classified as scheduled tribes, denotified, nomadic tribes and semi nomadic tribes. According to Salvi [5] the Mina forms the major tribe of Rajasthan followed by Saharia, Bheel/Bhil and Garasia. These tribes reside in specific localities of Aravallis and health care system of tribal pockets in Rajasthan is managed by various tribal healers viz. Bhopa (Ritual therapist), Jhankar / Jhangar (Herbalist), Devala (Grain diviner), Khoonth (Priest) and Guni (Herbal practitioner) [6-8]. For the documentation of functional properties of local fruits, an extensive survey was carried out of southern part of Rajasthan including Chittorgarh, Udaipur, Banswara and Dungarpur districts.

Material and methods
Ethno-medicinal field studies were carried out from 2015 to 2017 with following aims-

a. Documentation of ethno-medicinal plants.
b. Authentication of primary data.
c. Preparation of herbarium sheets.

A. Documentation of ethno-medicinal plants
- For the documentation of ethno-medicinal plants, field surveys were carried out all around the year from 2015 to 2017 in various tribal, rural and sub-rural pockets.
- Various localities of Southern Rajasthan (District-Udaipur, Dungarpur and Banswara) were selected to unearth the information from all the dominating tribes.
- For recording and documentation, field interviews were made from different practitioner’s i.e. ritual therapist, herbalist, grain diviner, priest and ancestral practitioner through local
transcends to avoid language ambiguity and data were recorded in information retrieval form.

- According to CBD guidelines prior informant consent (PIC) was obtained and inscribed for usage, dose, mode of dose, tenure/ time interval etc.

B. Authentication of primary data
In order to determine the authenticity of information collected during field visit, data was cross checked with published data of the same array and region. Data was also authenticated in criss cross manner by interviewing other informants.

C. Preparation of herbarium Sheets
Plant specimens were collected and herbarium sheets were prepared with all related information. Plants were identified up to species level through flora of region and prior work.

Table 1: Ethno-medical enumeration of functional fruits used by tribal’s of Southern Rajasthan to treat human diseases and disorders

<table>
<thead>
<tr>
<th>S. No</th>
<th>Botanical name; Family (Local name)</th>
<th>Plant part/s used</th>
<th>Form of usage; Application</th>
<th>Ailment/Disorder</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td><em>Acacia leucophloea</em> (Roxb.) Wild.; <em>Mimosaeae</em> (Ronj)</td>
<td>Unripe pods</td>
<td>Cooked as a vegetable</td>
<td>Demulcent</td>
</tr>
<tr>
<td>2.</td>
<td><em>Acacia nilotica</em> (L.) Del.; <em>Mimosaeae</em> (Bawal)</td>
<td>Pods</td>
<td>Powder is added to bread flour</td>
<td>Impotency</td>
</tr>
<tr>
<td>3.</td>
<td><em>Achyranthes aspera</em> L.; <em>Amaranthaceae</em> (Kantha)</td>
<td>Seeds</td>
<td>Roasted seed powder is mixed with wheat/ maize flour</td>
<td>Whooping cough</td>
</tr>
<tr>
<td>4.</td>
<td><em>Aegle marmelos</em> (L.) Corr.; <em>Rutaceae</em> (Bel)</td>
<td>Fruit pulp</td>
<td>Boiled pulp consumed orally</td>
<td>Dysentery &amp; Diarrhoea</td>
</tr>
<tr>
<td>5.</td>
<td><em>Alangium salviolium</em> (L.f.) Wang.; <em>Alangiaceae</em> (Ankol)</td>
<td>Ripe fruits</td>
<td>Eaten raw/Cooked as vegetable</td>
<td>High blood pressure</td>
</tr>
<tr>
<td>6.</td>
<td><em>Alloctopus cimicina</em> (L.) Stupf.; <em>Poaceae</em> (Basanti ghass)</td>
<td>Grains</td>
<td>Flour used for making bread</td>
<td>Diabetes &amp; Flatulence</td>
</tr>
<tr>
<td>7.</td>
<td><em>Amaranthus gangeticus</em> L.; <em>Amaranthaceae</em> (Kangani)</td>
<td>Seeds</td>
<td>Used as pseudocereal; boiled as rice</td>
<td>Constipation &amp; Liver tonic</td>
</tr>
<tr>
<td>8.</td>
<td><em>Bauhinia variegata</em> L.; <em>Caesalpiniaeae</em> (Kachnar)</td>
<td>Fruits</td>
<td>Powder is added to wheat flour</td>
<td>Diabetes</td>
</tr>
<tr>
<td>9.</td>
<td><em>Capparis decidua</em> (Forssk.) Edgew.; <em>Capparaceae</em> (Ker)</td>
<td>Unripe fruits</td>
<td>Used for the preparation of vegetable / pickle,</td>
<td>Digestive disorders</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ripe fruits</td>
<td>Eaten raw</td>
<td>Ashma</td>
</tr>
<tr>
<td>10.</td>
<td><em>Capparis sepiaria</em> L.; <em>Capparaceae</em> (Kanthor)</td>
<td>Ripe fruits</td>
<td>Eaten raw</td>
<td>Tumors</td>
</tr>
<tr>
<td>11.</td>
<td><em>Carissa congesta</em> Wt.; <em>Apocynaceae</em> (Karonda)</td>
<td>Unripe fruits</td>
<td>Cooked as a vegetable</td>
<td>Stone problems</td>
</tr>
<tr>
<td>12.</td>
<td><em>Coix lacryma-jobi</em> L.; <em>Poaceae</em> (Garelo)</td>
<td>Ripe fruits</td>
<td>Eaten raw or used in preparation of sausages</td>
<td>Stone problems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grains</td>
<td>Boiled and consumed as rice. Seeds along with <em>Zea mays / Triticum</em> are used for making porridge.</td>
<td>Dysentery, Diabetes &amp; Urinary complaints</td>
</tr>
<tr>
<td>13.</td>
<td><em>Cordia dichotoma</em> Forst. F; <em>Ehretiaceae</em> (Gunda)</td>
<td>Unripe fruits</td>
<td>Used as vegetable &amp; pickles</td>
<td>Biliousness</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ripe fruits</td>
<td>Eaten raw</td>
<td>Gastritis, Indigestion &amp; Constipation</td>
</tr>
<tr>
<td>14.</td>
<td><em>Cordia gharaf</em> (Forssk.) Ehrenb. ex. Asch.; <em>Ehretiaceae</em> (Gundi)</td>
<td>Ripe fruits</td>
<td>Eaten raw</td>
<td>Flatulence</td>
</tr>
<tr>
<td>15.</td>
<td><em>Cucumis callosus</em> (Rottl.)Cogn.; <em>Cucurbitaceae</em> (Kachri)</td>
<td>Fruits</td>
<td>Eaten raw or cooked as vegetable</td>
<td>Peptic ulcer</td>
</tr>
<tr>
<td>16.</td>
<td><em>Cucumis melo</em> L.; <em>Cucurbitaceae</em> (Garelo)</td>
<td>Fruits</td>
<td>Eaten raw or cooked as vegetable</td>
<td>Peptic ulcer</td>
</tr>
<tr>
<td>17.</td>
<td><em>Cyanopsis tetragonoloba</em> (L.)Taub; <em>Fabaceae</em> (Gaur)</td>
<td>Pods</td>
<td>Used as a vegetable</td>
<td>Asthma, Inflammation &amp; Sprain</td>
</tr>
<tr>
<td>18.</td>
<td><em>Echinocloa colonum</em> (L.) Link.; <em>Poaceae</em> (Sama)</td>
<td>Grains</td>
<td>Boiled and consumed as rice</td>
<td>Diabetes</td>
</tr>
<tr>
<td>19.</td>
<td><em>Echinocloa crusgalli</em> (L.) P.Beauv.; <em>Poaceae</em> (Sama)</td>
<td>Grains</td>
<td>Boiled and consumed as rice</td>
<td>Diabetes &amp; Nostril hemorrhage</td>
</tr>
<tr>
<td>20.</td>
<td><em>Elusine coruncana</em> (L.) Gaertn.; <em>Poaceae</em> (Garelo)</td>
<td>Grains</td>
<td>Boiled and consumed as rice</td>
<td>Diabetes &amp; Fever</td>
</tr>
<tr>
<td>21.</td>
<td><em>Ensete superbum</em> (Roxb.) Chees; <em>Musaceae</em> (Jungli kela)</td>
<td>Fruits</td>
<td>Consumed raw</td>
<td>♀ Contraceptive</td>
</tr>
<tr>
<td>22.</td>
<td><em>Feronia limonia</em> (L.) Swingle; <em>Rutaceae</em> (Kotambadi)</td>
<td>Ripe fruits</td>
<td>Consumed raw and also used for the preparation of chutney.</td>
<td>Diabetes &amp; Leucorrhea</td>
</tr>
<tr>
<td>23.</td>
<td><em>Grewia hirutula</em> Vahl.; <em>Tiliaceae</em> (Gurushira)</td>
<td>Ripe fruits</td>
<td>Consumed raw</td>
<td>Dysentery</td>
</tr>
<tr>
<td>24.</td>
<td><em>Grewia tenax</em> (Forssk.) Fiori.; <em>Tiliaceae</em> (Gangir)</td>
<td>Ripe fruits</td>
<td>Consumed raw</td>
<td>Dysentery</td>
</tr>
<tr>
<td>25.</td>
<td><em>Holoptelea integrifolia</em> (Roxb.) Planch.; <em>Ulmaceae</em> (Bandarbatti)</td>
<td>Seed kernels</td>
<td>Eaten raw</td>
<td>Skin eruptions</td>
</tr>
<tr>
<td>26.</td>
<td><em>Ipomoea pes-tigris</em> L.; <em>Convolvulaceae</em>(Ghebatti)</td>
<td>Seeds</td>
<td>As a powder used for bread preparation</td>
<td>Gastric troubles</td>
</tr>
<tr>
<td>27.</td>
<td><em>Lagenaria siceraria</em> (Molina.) Standl.; <em>Cucurbitaceae</em> (Tumbi)</td>
<td>Fruits</td>
<td>Used as a vegetable</td>
<td>Jaundice</td>
</tr>
</tbody>
</table>
Result and Discussion

Documentation of ethno-functional food from southern Rajasthan reveals usage of 50 Aegle marmelos and their respective components for different maladies. In order to correct water mediated diarrhea fruit pulp of Aegle marmelos is consumed orally. Aegle marmelos, Coix lacryma-jobi, Grewia hirsute, Grewia tenax and Paspalum scrobiculatum are used to check dysentery. Flowers and fruits of Madhuca indica are utilized as raw or cooked as vegetable and thereafter consumed to cure dysentery. These herbs are either cidal or static against the microbes. They block the anabolic pathway by subsidizing the tuberculosis. These herbs are then made into a powder and subsequently consumed to cure tumors. Favanoids are effective anti-tumor molecules therefore plants with rich pool of flavanoid may help in tumor healing, personality changes and finally death.

Scurvy results due to lack of vitamin C (ascorbic acid). Early symptoms include weakness, feeling of tiredness and sore arms and legs. Without treatment, decreased red blood cells, gum disease, changes in hair morphology and bleeding from the skin may occur. As scurvy worsens there can be significant clotting defects, anemia and bleeding. As scurvy worsens there can be significant clotting defects, anemia and bleeding.

Informants were not aware about the concept of malignancy with respect to cancer and tumor. Therefore, the plant usages in cases where the patient was clinically diagnosed for cancer were included in cancer subcategory while all clinically undiagnosed masses of tissues were included under tumors. No plant source based usage was cited for cancer whereas one citation i.e. raw fruits of Capparis sepaptera are used to get rid off for tumors. Favanoids are effective anti-tumor molecules therefore plants with rich pool of flavanoid may help in tumor healing, personality changes and finally death.

With respect to nutritional disease/s no supplementary functional food or drugs are ingested. Obesity is considered to be outcome of over eating and they do not relate it as an output to any other metabolic disorder. Syzygium heyneanum is used to combat obesity and diabetes.

In present documentation diabetes refers to diabetes mellitus II. Fifteen plants viz. Alloeteropsis cimicina, Bauhinia variegate, Coix lacryma-jobi, Echinocloa colomum, Echinocloa

| No. | Plant Name | Family | Parts Used | Preparation | Symptoms | Malady
|-----|------------|--------|------------|------------|----------|--------
| 28. | Leptadenia reticulata (Retz.) Wt. & Arn.; Asclepiadaceae (Chiep) | | Unripe fruits | Eaten raw as a vegetable | | Arthritis & Rheumatism
| 29. | Madhuca indica J. F. Gmelin; Sapotaceae (Mahua) | | Fruits | Eaten raw and also cooked as vegetable | | Tuberculosis & Eczema
| 30. | Minnesops elengi L.; Sapotaceae (Khirni) | | Ripe fruits | Fruits are eaten raw | | Mouth boils & Tonsillitis
| 31. | Moringa concanensis N. ex Dalz. & Gibs.; Moringaceae (Sargana) | | Pods | Used as a vegetable | | Bilioussness & Flatulence
| 32. | Moringa oleifera Lamk.; Moringaceae (Sargana) | | Pods | Used as a vegetable | | Arthritis, Rheumatism & Inflammation
| 33. | Morus alba L.; Moraceae (Shatat) | | Fruits | Eaten raw | | Goiter
| 34. | Mucuna pruriens (L.) DC; Fabaceae (Kuanch) | | Unripe fruits | Eaten raw and/ used for the preparation of Konch pak | | General debility & Low BP
| 35. | Panicum miliaceum L.; Poaceae (Samlai) | | Grains | Flour used for making bread | | Diabetes
| 36. | Panicum sumarentes Schult.; Poaceae (Samlai) | | Grains | Flour used for making bread | | Diabetes
| 37. | Paspalidium flavidum (Retz.) A.Camus; Poaceae (Samlai) | | Grains | Flour used for making bread | | Diabetes
| 38. | Paspalum scrobiculatum L.; Poaceae (Kodra) | | Grains | Boiled and consumed as rice | | Diabetes & Dysentry
| 39. | Pedaliun murex L.; Pedaliaceae (Bada Gokhru) | | Fruits | Powder added to bread | | General Debility
| 40. | Pithecocodium dulce (Roxb.) Benth.; Mimosaceae (Kikar) | | Aril | Eaten raw | | Demulcent
| 41. | Salvadorac persica L.; Salvadoraceae (Pilu) | | Fruits | Eaten raw | | Scurvy & Rheumatism
| 42. | Setaria glauca (L.) P. Beauv.; Poaceae (Kukarva) | | Grains | Flour used for making bread | | Diabetes
| 43. | Setaria italic (L.) P. Beauv.; Poaceae (Kangini) | | Grains | Flour used for making bread | | Diabetes & Dysuria
| 44. | Solanum nigrum L.; Solanaceae (Makao) | | Fruits | Eaten raw | | Cold and Cough
| 45. | Spindias mangifera Willd.; Anacardiaceae (Parangi) | | Fruits | Eaten raw | | Apnea
| 46. | Sycygium heyneanum (L.) P. Beauv.; Myrtaceae (Jungle jamun) | | Fruits | Eaten raw or used as a vinegar | | Diabetes & Obesity
| 47. | Tribulus terrestris L.; Zygophyllaceae (Gokhru) | | Seeds powder | Flour used for bread during famines | | Urinary infections & Kidney dysfunction
| 48. | Trichosanthes anguina L.; Cucurbitaceae (Chachinda) | | Fruits | Consumed as a vegetable | | Diabetes & Bronchitis
| 49. | Ziziphus glabrata Heyne ex Roth.; Rhamnaceae (Bor) | | Fruits | Eaten raw | | Leucorrhea
| 50. | Ziziphus nummuariia (Burm. F.) Wt. & Arn.; Rhamnaceae (Jhari Bor) | | Fruits | Eaten raw | | Leucorrhea & Constipation
crussgalli, Eleusine coracana, Feronia limonia, Panicum miliaceum, Panicum sumatrense, Paspalidium flavidum, Paspalum scrobiculatum, Setaria glauca, Setaria italic, Syzygium heynemanum and Trichosanthes anguina are used to reduce high glycemic levels. As earlier reported the active component of these plants effectively seizes post prandial hyperglycemia.[11-14]

Among other endocrine maladies only one plant Morus alba was reported to be used in iodine related thyroid dysfunction although there was no cited demarcation for hypothyroidism and hyperthyroidism. These fruits are used in goiter suppression which is accordance to the earlier report by Ghosh et al. [15].

Sleep-wake disorders were least observed among the populations except in the aged[ly]. Spondias mangifera was reported to be used in apnea. Probably it slows down the nervous system, which relaxes the body [16].

Mucuna pruriens is used to elevate and regulate low blood pressure whereas Alangium salviifolium are used to lower high blood pressure. Probably these plants possess angiotensin converting enzyme inhibitor activity due to which they act as cardiotonic and reduce hypertension [17].

Achyranthes aspera, Solanum nigrum, Spondias mangifera and Trichosanthes anguina are used as remedial source in respiratory diseases. Bauhinia variegata and Mimulus elengi were used to refrain from tussilitis. Ethnically Capparis deciduas and Cyamopsis tetragonoloba are used by patients of asthma. When an asthma patient comes in contact with an allergic substance, it behaves as an antigen and reacts with the corresponding antibodies already present in patients bodies. The histamine and other substances liberated during the allergic reactions cause the damage in the bronchi. Plants having biomolecules that can repair mast cells of bronchi serve as anti asthmatic or serve as leukotriene antagonists [18-20].

Undefined and combined symptoms including nausea or recurrent upset stomach, abdominal bloating and pain, vomiting, indigestion and/or loss of appetite are termed under common category as gastric problems [21]. Allotropis cimicina, Amaranthus gangeticus, Capparis deciduas, Cordia dichotoma, Cordia gharaf, Cucumis callosus, Cucumis melo Ipomoea pes-tigridis, Mimulus elengi, Moringa concanensis and Ziziphus nummularia are used to cure mouth boils, gastritis, flatulence, indigestion, constipation and peptic ulcer. Liver is a chief detoxifying organ of the body. Liquor consumption with sub standard practices predominates in tribal patches. Many plants are used in various forms for the restoration and regeneration of hepatic cells. The present study reveals usage of Lagenaria sicerraria in jaundice and application of boiled grains of Amaranthus gangeticus and Ziziphus nummularia are used as liver tonic. According to local therapist Carissa congoesta is used to get rid of stone problems but they were unable to demarcate between kidney and gall bladder stones (Table 1).

The primary function of the skin is to serve as a protective barrier against the environment. Loss of the integrity of large portions of the skin as a result of injury or illness may lead to major disability or even death. Wounds and cuts are the major entry doors of microbial world and in due time clogs the tissue [22]. Delayed wound healing sometimes leads to ulceration which becomes more crucial in diabetic patients. Holopetelia integrifolia is reported to enhance skin eruptions. Plants with metalloproteinase synthesizing capabilities promote wound healing through multiple routes and therefore are deployed ethnically [23, 24]. Acacia leucophloea and Pithecellobium dulce are used as demulcent.

Madhuca indica is used as topical over infected parts of skin. Eczema is a term for a group of medical conditions that cause the skin to become inflamed or irritated. The most common type of eczema is known as atopic dermatitis or atopic eczema. The exact cause of eczema is unknown, but it’s thought to be linked to an overactive response by the body's immune system to an irritant. Generally it is imposed by fungal moieties. Therefore, plants that boost immunity or have antifungal properties serve as phyto drug in eczema [25].

Cyamopsis tetragonoloba, Leptadenia reticulate, Moringa oleifera and Salvadora persica are used to cure muscular anomalies and bone deformities. Enzymatic degradation of hypoxanthine and xanthine leads to the production of uric acid. Elevated concentrations of uric acid in the blood stream of human body leads to formation of gout, characterized by hyperuricemia and recurrent attacks of arthritis. Xanthine oxidase is an enzyme responsible for catalyzing the oxidation of hypoxanthine to xanthine and xanthine to formation of uric acid. The treatment of gout entails the use of therapeutic agents such as xanthine oxidase inhibitors which acts by blocking the biosynthesis of uric acid from purine in the body and it is believed that either by increasing the excretion of uric acid or reducing the uric acid production helps to reduce the risk of gout [26].

Among different genital diseases Feronia limonia, Ziziphus glabrata and Ziziphus nummularia are used for leucorrhea. Coix lacryma-jobi, Setaria italic and Tribulus terrestris are used to treat urinary infections. Urinogenital disorders include bladder cancer, cystocele, hematuria, impotence / erectile dysfunction, interstitial cystitis, male factor infertility, neurogenic bladder, Peyronie’s disease, benign prostatic hyperplasia and prostate cancer. Informants claim uses of Tribulus terrestris to treat renal dysfunction. Renal maladies include tubular necrosis, acute interstitial nephritis, Fanconi's syndrome, hypokalemia or hyperkalemia, hypertension, papillary necrosis, chronic interstitial nephritis, nephrolithiasis, urinary retention and cancer of the urinary tract. Tribulus might promote effective filtration by restoring the effective equilibrium between afferent and efferent filtration pressures [27].

In the studied region many applications and medications were reported to be gender based. No male oral contraceptive medications were cited by informants while Ensete superbum is used as a femalely contraceptive. Many of these medicinal plants appear to act through an antizygotic mechanism either they inhibit sperm head activation or changes the biochemical milieu of developed eggs [28].

Similarly aphrodisiacs are used by male members and no report regarding usages in female has been reported. Acacia nilotica are used to energize, vitalize and improve sexual function whereas Mucuna pruriens and Pedalium murex are used to treat general debility. These function either by increasing testosterone or activate melanocortin receptors MC3/4-R [29].

Fever (also known as pyrexia or controlled hyperthermia) is a condition when a human’s body temperature goes above the normal range of 36-37 °C. In the study area, the fever is common and frequent. Local therapist deploy many plants as therapeutics but only Eleusine coracana is used as a remedial food for the same but the informants were not aware about the causal sources of fever and therefore were treated in general. Ethno-medicinal survey also reveals that in 68% applications fruits and pods are deployed as a whole unit whereas in aril is deployed in 2% disease and 30% applications involve usage of seeds and grains.42% fruits and their parts are eaten raw while
25% are used as vegetable, 21% grains are used as flour for bread while 10% are consumed as boiled rice. Only 2% fruits are used as decoction to check/regulate anomalies.

References