

Ethno veterinary approaches to mitigate heat stress in small ruminants

M. Shahzad¹, M. Naeem^{1*}, N. Rajput², A.A. Behan¹, M.J. Sheikh³, L. Rodini⁴, A. Kabir^{*5}

¹Department of Livestock Management, ²Department of Poultry Husbandry, ⁵Department of Veterinary Microbiology, Faculty of Animal Husbandry and Veterinary Sciences; ³Department of Rural Sociology, ⁴Department of Statistics, Faculty of Agriculture Social Sciences Sindh Agriculture University Tandojam, Pakistan. Corresponding author e-mail: mnrajput@sau.edu.pk, kabirvet32@gmail.com

Journal of Livestock Science (ISSN online 2277-6214) 17: 733-743
Received on 23/4/26; Accepted on 4/9/26; Published on 13/9/26
doi. 10.33259/JLivestSci.2026.733-743

Abstract

Heat stress poses a significant threat to small ruminant health and productivity in subtropical regions, particularly in Sindh, Pakistan, where prolonged heat waves and high ambient temperatures are common. This study documented ethnoveterinary practices used by local healers, pastoralists, and small ruminant farmers across seven districts of Sindh to manage heat stress in sheep and goats. A cross-sectional survey was conducted using semi-structured questionnaires and face-to-face interviews with 210 respondents. A total of 73 natural remedies were documented, including 63 medicinal plant species from 36 families, 6 mineral sources, and 4 animal-derived products. Plant-based remedies dominated (86.1%), followed by mineral (8.3%) and animal sources (5.6%). The most frequently used plant families were Fabaceae, Cucurbitaceae, and Rosaceae. Seeds (28.6%) and leaves/stems (23.8%) were the most commonly utilized plant parts. Among animal remedies, buttermilk (95%) and yogurt (57%) were preferred for hydration and rumen health. Mineral supplements including pink salt (57%) and black salt (43%) were widely used for electrolyte balance. The majority of remedies (97%) were administered orally. These ethnoveterinary practices are cost-effective, culturally accepted, and locally available, offering sustainable strategies for mitigating heat stress. The high ethnobotanical diversity and strong indigenous knowledge documented in this study provide a foundation for developing climate-resilient livestock management systems. Scientific validation of these traditional remedies through phytochemical and pharmacological studies is recommended.

Keywords: Ethnoveterinary medicine; heat stress; small ruminants; indigenous knowledge; climate resilience

Introduction

High environmental temperatures pose one of the most significant constraints to sheep and goat health and productivity (Zhang et al. 2021), particularly in subtropical regions such as Sindh, Pakistan, where prolonged heat waves coincide with extreme ambient temperatures and aridity (Khalid et al. 2025). Among small ruminants, sheep are inherently less heat-tolerant than goats due to their poorly developed sweat glands, limited respiratory heat dissipation, dense hair coats, and restricted behavioral thermoregulation (dos Santos et al. 2021). Chronic heat stress disrupts physiological homeostasis, depresses feed intake, compromises immune function, impairs reproductive performance, and ultimately undermines animal health, welfare, and productivity (Lacetera 2019; Mahjoubi et al. 2015; Inbaraj et al. 2016). Consequently, effective heat stress management is imperative for sustaining small ruminant production in hot climates.

Livestock is the cornerstone of Pakistan's agricultural economy, contributing approximately 63.6% of agricultural value added and 14.97% of the national Gross Domestic Product (GDP) in fiscal year 2024-25. Small ruminants form a substantial share of the national herd, with an estimated 89.4 million goats and 33.1 million sheep. Sindh province alone houses over 49.9 million livestock animals, including nearly 19 million goats and 4.74 million sheep, most of which are reared under harsh climatic conditions. These species are vital to rural livelihoods, supplying meat, milk, wool, hides, and consistent income, especially for landless and smallholder farmers in arid and semi-arid zones (Bettencourt et al. 2013). Thus, the productivity and well-being of small ruminants directly influence rural income stability and national food security.

Climate change has intensified the vulnerability of small ruminant production systems through rising temperatures, more frequent and severe heat waves, water scarcity, and diminished forage availability (Hashem et al. 2023). Conventional heat stress mitigation strategies typically include housing modifications, improved ventilation, shearing, provision of cool drinking water, bathing, and dietary adjustments (Torbat Esfahani et al. 2024). However, ethnoveterinary practices are gaining recognition as cost-effective, culturally grounded, and environmentally sustainable adaptation alternatives (Vaarst & Alrøe 2012). These practices harness locally available medicinal plants and herbs with documented cooling, antioxidant, electrolyte-balancing, digestive, and immune-supporting properties, alongside traditional grazing and housing systems (Zhou et al. 2019; Shinde & Sejian 2013).

Sindh's rich ethnoveterinary heritage is deeply rooted in the Indus River basin, which historically provided fertile soils, diverse ecosystems, and extensive trade routes that enabled cultural exchange and the diffusion of traditional medical knowledge (Shoaib et al. 2021). Over generations, rural communities have accumulated extensive indigenous knowledge of medicinal plants for both human and livestock treatment (Mirani et al. 2014a). Chicory (*Cichorium intybus*), mint (*Mentha* spp.), and *Polygonum bistorta* are among the most commonly used species, valued for their cooling, hydrating, hepatoprotective, and body-strengthening effects against heat stress (Aziz et al. 2018). Against this backdrop, the present study seeks to systematically document and scientifically contextualize the ethnoveterinary practices employed by local healers to manage heat stress in small ruminants across Sindh.

Materials and Methods

Study area

The study was conducted in Sindh Province, Pakistan, across seven districts: Tando Muhammad Khan, Hyderabad, Tando Allahyar, Mirpur Khas, Matyari, Shaheed Benazir Abad, and Jacobabad. These districts are characterized by high ambient temperatures, making them suitable for investigating heat stress management strategies in small ruminants. Sindh is a major agricultural region in southern Pakistan, situated approximately between 23.5° N and 30° N latitude and 68° E and 77° E longitude. The province experiences a tropical desert climate, marked by high temperatures, low annual rainfall, and distinct seasonal variations. Average temperatures range from 25°C to 35°C (77°F to 95°F). Winter months (December to February) can see nighttime temperatures dropping to 5°C, while summer months (May to July) frequently record extreme highs reaching 50°C (122°F). Sindh's diverse geography and proximity to the Arabian Sea significantly influence its climatic patterns, rendering it a critical region for livestock farming, particularly in rural and peri-urban areas.

Ethical statement

This study was conducted in accordance with the ethical guidelines for research involving traditional knowledge and livestock keepers. Prior informed consent was obtained from all participants before data collection. The study protocol was reviewed and approved by the relevant institutional ethics committee (approval number and name to be added as required).

Selection of study districts and respondents

A cross-sectional ethnoveterinary survey was carried out across the seven selected districts. The districts were purposively chosen based on their high livestock density, historical prevalence of extreme heat events, and accessibility for field research. In each district, thirty respondents were selected using a combination of snowball and purposive sampling techniques. The total sample size comprised 210 participants, including ethnoveterinary healers (EVHs), pastoralists, and small-ruminant farmers.

Data collection instruments and procedures

A semi-structured questionnaire was developed following the methodology of Martin (1995) as adapted by Aziz et al. (2018). The questionnaire was designed to capture detailed information on locally used medicinal plants, preparation methods, routes of administration, dosage forms, and perceived efficacy in mitigating heat stress in sheep and goats. Data were collected through face-to-face interviews conducted in the local language (Sindhi) to ensure clear communication and accurate recording of indigenous knowledge. Each interview lasted approximately 45 to 60 minutes. Field notes were taken, and plant specimens mentioned by respondents were collected for taxonomic identification.

It is important to note that this study is a cross-sectional survey designed to document existing indigenous knowledge and reported practices. The claimed efficacy of these remedies has not been experimentally verified on the authors' own farms or through controlled in-vivo trials at the time of this study. Therefore, the reported therapeutic outcomes are based on the respondents' observations and traditional beliefs, and future experimental validation is strongly recommended.

Plant identification and authentication

Medicinal plant species reported by respondents were collected during the field surveys. Specimens were pressed, dried, and mounted following standard herbarium procedures. Taxonomic identification was performed using relevant floral manuals and by comparison with authenticated herbarium specimens. Voucher specimens were deposited at a recognized herbarium (name and code to be added) for future reference.

Data analysis

The collected data were compiled and analyzed using descriptive statistics. Plant use value (UV), informant consensus factor (ICF), and fidelity level (FL) were calculated following standard ethnobotanical methods to determine the relative importance and cultural significance of each reported plant species. Results are presented as frequencies, percentages, and mean values where applicable.

Results

Socio-demographic profile of respondents

The socio-demographic characteristics of the surveyed farmers, pastoralists, and nomads ($n = 210$) are presented in Table 1. The majority of respondents (85%) were within the economically active age bracket of 16–45 years, while only 15% were aged 46 years or above. Regarding educational attainment, 42% had primary education, 38% were illiterate, and only 8% held a graduate degree. In terms of livestock rearing experience, 70% of respondents had 5–35 years of experience, 20% had less than 5 years, and 10% had more than 35 years, indicating that most participants were well-exposed to practical animal husbandry.

Table 1. Demographic information of respondents.

Variable	%
Age	
16–45	85
>46	15
Education	
Illiterate	38
Primary	42
Matric	7
Intermediate	5
Graduation	8
Experience (years)	
<5	20
5–35	70
>35	10

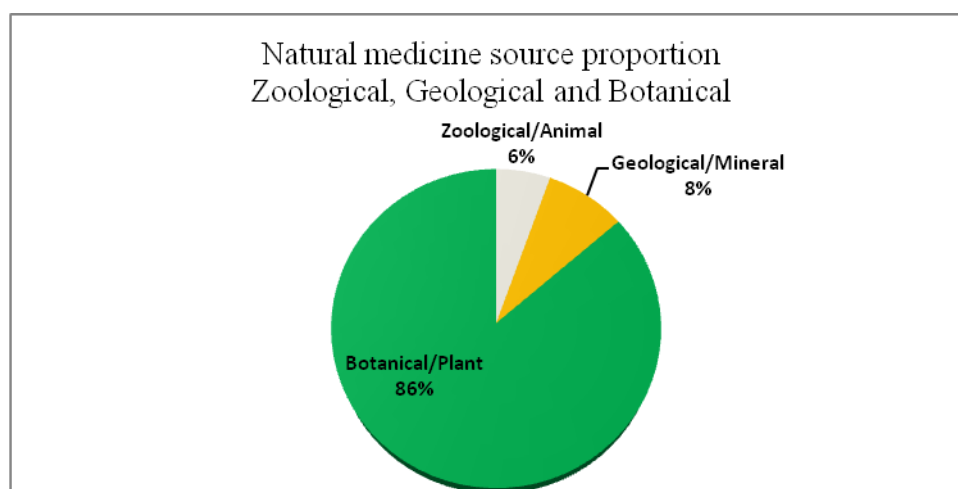


Figure 1. Proportion of natural medicine sources used for prophylaxis and management of heat stress in small ruminants.

Table 2. Frequency of animal-derived natural elements for heat stress management in small ruminants.

S. No	Animal source	Vernacular name	Dose	Frequency (n=210)
1	Honey	Shahed	5–15 g	14
2	Milk	Dood	40–100 mL	70
3	Yogurt	Dahi	30–80 mL	120
4	Buttermilk	Lassi	50–200 mL	200

Table 3. Frequency of mineral-derived natural elements for heat stress management in small ruminants.

S. N.	Mineral	Formula	Vernacular name	Dose (g)	Administration	Frequency (n=210)
1	Fuller's earth, bentonite	$(Al,Mg)_2Si_4O_{10}(OH)_2 \cdot nH_2O$	Multani mitti	10–20	Topical & oral	40
2	Ammonium chloride	NH_4Cl	Noshadar	1–3	Oral	54
3	Black salt	$NaCl$	Kala namak	0.5–2	Oral	90
4	Pink salt/Himalayan salt	$NaCl$	Lohari namak	1–3	Oral	190
5	Potassium nitrate	KNO_3	Qalmi shora	1–3	Oral	60
6	Potassium carbonate	K_2CO_3	Jokhar	1–2	Oral	35

Sources of natural medicines

The survey evaluated the sources of natural medicines used by respondents for livestock health management (Figure 1). Plant-based remedies constituted the majority (86.1%), followed by geological/mineral sources (8.3%) and zoological/animal sources (5.6%). This distribution indicates a strong preference for plant-based solutions, likely due to local abundance, traditional knowledge, and perceived efficacy.

Animal-derived remedies

Ethnoveterinary healers in Sindh employ several animal-derived remedies to manage and prevent heat stress (Table 2). Buttermilk (*Lassi*) was the most commonly used (95% of respondents; 50–200 mL), followed by yogurt (*Dahi*; 57%; 40–100 mL), milk (*Dood*; 33%; 40–100 mL), and honey (*Shahed*; 7%; 5–15 g with 50–100 mL water). Yogurt is valued for its probiotic effects on digestion during hot weather.

Mineral-derived remedies

A variety of mineral sources are used for heat stress management (Table 3). Pink salt (*Lohari namak*) was the most frequently used (57%; 1–3 g orally), followed by black salt (*Kala namak*; 43%; 0.5–2 g), potassium nitrate (*Qalmi shora*; 29%; 1–3 g), ammonium chloride (*Noshadar*; 26%; 1–3 g), Fuller's earth (*Multani mitti*; 19%; 10–20 g topical/oral), and potassium carbonate (*Jokhar*; 17%; 1–2 g).

Medicinal plant species used

A total of 63 medicinal plant species belonging to 36 families were documented (Table 4A and 4B). The dominant family was Fabaceae (6 species), followed by Cucurbitaceae and Rosaceae (4 species each), and Apiaceae, Lamiaceae, and Solanaceae (3 species each). Apocynaceae, Asteraceae, Malvaceae, Papaveraceae, Plantaginaceae, Poaceae, Polygonaceae, Zingiberaceae, and Zygophyllaceae each contributed 2 species. The remaining 21 families contributed one species each.

Table 4A. Medicinal plants used by ethnoveterinary healers for heat stress management in small ruminants (Plants 1–31).

S. No	Family	Plant species	Vernacular name	Habit	Class	Part used	Dose (g/mL)	Frequency (n=210)
1	Amaryllidaceae	<i>Allium cepa</i>	Piyaz	H	Ve	B	10-30	80
2	Anacardiaceae	<i>Mangifera indica</i>	Kayri	T	Fr	UP	15-30	85
3	Apiaceae	<i>Coriandrum sativum</i>	Dhanya	H	C & Sp	L & S	20-50 & 5-10	110
4	Apiaceae	<i>Cuminum cyminum</i>	Zeera sufaid	H	Sp	S	2-3	70
5	Apiaceae	<i>Foeniculum vulgare</i>	Soonf	H	Sp	S	5-15	160
6	Apocynaceae	<i>Holarrhena antidysenterica</i>	Andar jo talkh	Sh	M	B	2-4	20
7	Apocynaceae	<i>Carissa carandas</i>	Karonda	Sh	Ve & Fr	F	10-20	30
8	Arecaceae	<i>Cocos nucifera</i>	Khopra	T	Fr	F	20-40	45
9	Asphodelaceae	<i>Aloe barbadensis</i>	Kanwargandal	H	M	Gl	10-30	110
10	Asteraceae	<i>Cichorium intybus</i>	Kasni	H	M	S	3-6	170
11	Asteraceae	<i>Sphaeranthus indicus</i>	Gull e Mundi	H	M	Fl	5-10	20
12	Berberidaceae	<i>Berberis vulgaris</i>	Zarishk	Sh	Fr	F	5-10	120
13	Brassicaceae	<i>Brassica napus/juncea</i>	Sarsoon	H	Os & Sp	S & O	5 & 15	190
14	Cannabaceae	<i>Cannabis indica</i>	Bhang	H	M	L	2-5	60
15	Cucurbitaceae	<i>Citrullus lanatus</i>	Tarbooz	H	Fr	F & S	150 & 2-5	115
16	Cucurbitaceae	<i>Cucumis melo</i>	Kharboza	H	Fr	F & S	100 & 2-5	118
17	Cucurbitaceae	<i>Cucurbita pepo</i>	Kadu tukhm	H	Ve	F & S	50-100 & 1-3	40
18	Cucurbitaceae	<i>Cucumis sativus</i>	Kheera tukhm	H	Ve	S	1-3	45
19	Fabaceae	<i>Acacia nilotica</i>	Babool	T	M	B & G	10-20 & 2-5	70
20	Fabaceae	<i>Astragalus gummifer</i>	Gond kateera	Sh	M	G	3-5	140
21	Fabaceae	<i>Baptisia australis</i>	Sarphoka	H	M	WP	2-5	20
22	Fabaceae	<i>Dalbergia sissoo</i>	Shesham	T	M	B & L	10-20 & 40	130
23	Fabaceae	<i>Pterocarpus santalinus</i>	Sandal surkh	T	M	W	2-5	120
24	Fabaceae	<i>Senna alexandrina</i>	Sanna	H	M	L	2-5	40
25	Fabaceae	<i>Tamarindus indica</i>	Imli	T	Sp	P	5-15	140
26	Gentianaceae	<i>Swertia chirata</i>	Charaeta	H	M	WP	2-5	40
27	Lamiaceae	<i>Mentha</i>	Podena	H	C	L	3-7	170
28	Lamiaceae	<i>Ocimum basilicum</i>	Tukhm balango	H	M	S	5-10	160
29	Lamiaceae	<i>Vitex agnus-castus</i>	Sanbhalu	Sh	M	L & RB	3-7 & 2-5	20
30	Lythraceae	<i>Punica granatum</i>	Anar	Sh	Fr	F & S	10-30	165
31	Malvaceae	<i>Grewia asiatica</i>	Falsa	Sh	Fr	F	10-30	174

Dose Distribution and Therapeutic Patterns

Examination of the 63 plant species revealed a well-stratified dose range of 0.5–150 g/mL. Most taxa (two-thirds) fell within the 2–10 g therapeutic range, indicating a low-to-moderate dosing approach. Medicinal herbs such as *Polygonum bistorta*, *Rheum emodi*, *Withania coagulans*, *Swertia chirata*, and *Holarrhena antidysenterica* were used at 2–4 g. Spices including *Cuminum cyminum* (2–3 g), *Piper nigrum* (1–2 g), and *Elettaria cardamomum* (0.5–1 g) represented the lowest dose bracket due to high essential oil content and strong bioactivity. A second cluster (5–20 g) included antioxidant-rich fruits and seeds such as *Phyllanthus emblica*, *Sesamum indicum*, *Ocimum basilicum*, *Plantago ovata*, and *Foeniculum vulgare*. Middle-range doses (10–30 g) were observed for *Moringa oleifera* leaves, *Aloe barbadensis* gel, and *Acacia nilotica* bark, indicating nutritive-tonic rather than acute pharmacological effects. Higher doses (>30 g/mL) were associated with hydrating fruits and energy substrates, notably *Citrullus lanatus* pulp (150 g), *Cucumis melo* (100 g), and *Saccharum officinarum* juice (30–60 mL), suggesting their role as cooling, rehydrating, and energy-enriching agents.

Plant Habit, Class, and Part Used

Plant Habit

As shown in Figure 2, herbs constituted the majority (43%, n = 27), followed by trees (22%, n = 14), shrubs (17.5%, n = 11), vines or creepers (9.5%, n = 6), grasses (3.2%, n = 2), and plant products (4.8%, n = 3). The predominance of herbaceous species reflects their ease of access, rapid regeneration, and concentration of bioactive compounds.

Plant Class

Figure 3 shows that medicinal plants dominated (52%, 33 species), followed by fruits (16%, 10 species). Dual-function categories included spice/medicine (10%, 6 species), fruit/medicine (2%), fruit/spice (3%), oilseed/spice (2%), oilseed/medicine (2%), vegetable/medicine (2%), and spice/culinary (2%). Pure spices accounted for 6% (4 species) and oilseeds for 4%. Approximately one-fifth of the species exhibited combined culinary-medicinal effects, highlighting the food-medicine continuum in the study community.

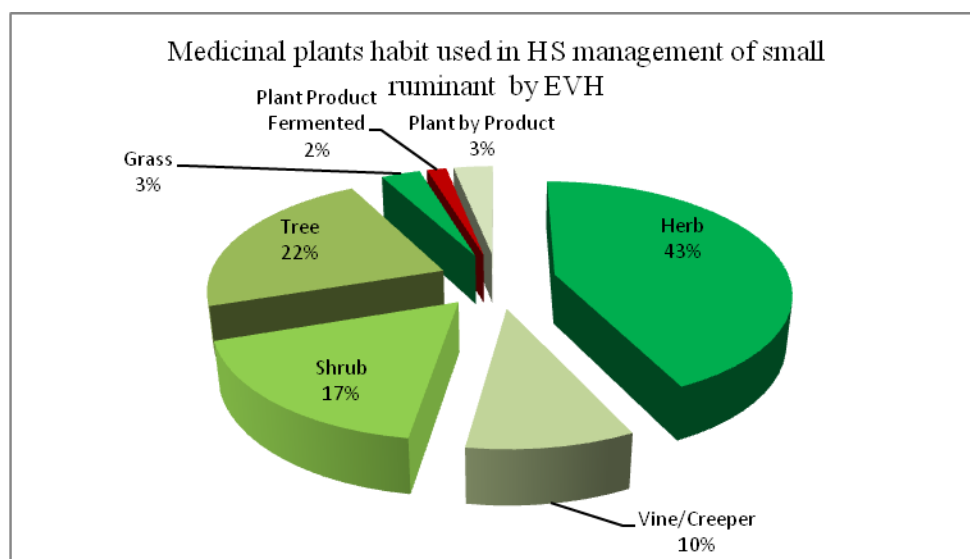
Table 4B. Medicinal plants used by ethnoveterinary healers for heat stress management in small ruminants (Plants 32–63).

S. No	Family	Plant species	Vernacular name	Habit	Class	Part used	Dose (g/mL)	Frequency (n=210)
32	Malvaceae	<i>Hibiscus rosa-sinensis</i>	Gurhal	Sh	M	Fl & RB	10-20	80
33	Manispermaceae	<i>Tinospora cordifolia</i>	Gilo bail	H/Vi	M	L & W	3-10	115
34	Meliaceae	<i>Azadirachta indica</i>	Neem	T	M	L & Fl	15 & 5	128
35	Moraceae	<i>Morus nigra</i>	Toot	T	Fr	F	10-30	50
36	Moringaceae	<i>Moringa oleifera</i>	Sohanjna	T	M	L	10-30	45
37	Nelumbonaceae	<i>Nelumbo nucifera</i>	Gull Nilofar	H	M	Fl	5-15	74
38	Papaveraceae	<i>Fumaria officinalis</i>	Shahtra	H	M	WP	2-5	23
39	Papaveraceae	<i>Papaver somniferum</i>	Khashkhash	H	M	S	2-3	47
40	Pedaliaceae	<i>Sesamum indicum</i>	Til	H	Os & M	S	5-20	39
41	Phyllanthaceae	<i>Phyllanthus emblica</i>	Amla	Sh	Fr & M	F	5-20	113
42	Piperaceae	<i>Piper nigrum</i>	Mirch siyah	H	Sp	S	1-2	61
43	Plantaginaceae	<i>Bacopa monnieri</i>	Barhami booti	H	M	L	5-10	18
44	Plantaginaceae	<i>Plantago ovata</i>	Isapgol	H	M	S & Hk	5-15	102
45	Poaceae	<i>Cymbopogon citrates</i>	Lemon grass	G	M	L	5-15	33
46	Poaceae	<i>Saccharum officinarum</i>	Ganna ka ras / Gur	G	Sc	J	30-60 / 5-20	181
47	Polygonaceae	<i>Polygonum bistorta</i>	Anjbar	H	M	R	2-5	176
48	Polygonaceae	<i>Rheum emodi</i>	Rayvand cheni	H	M	R	2-5	23
49	Rhamnaceae	<i>Ziziphus jujube</i>	Unnab	Sh	M	F	5-10	41
50	Rosaceae	<i>Malus domestica</i> (ethanoic acid)	Saib ka sirka	T	M	FJ	3-10	53
51	Rosaceae	<i>Prunus dulcis</i>	Badam	T	DF	S	3-10	32
52	Rosaceae	<i>Prunus domestica</i>	Aalu bukhara	T	Fr	F	15-40	139
53	Rosaceae	<i>Rosa</i>	Gulab gull	Sh	M	Fl	5-20	74
54	Rutaceae	<i>Citrus limon</i>	Lemon	Sh	C & Fr	J	5-10	142
55	Santalaceae	<i>Santalum album</i>	Sandal sufaid	T	M	W	2-5	130
56	Smilacaceae	<i>Smilax</i>	Ushba	H	M	R	2-5	24
57	Solanaceae	<i>Capsicum annuum</i>	Green Chilli	H	Sp & Ve	F	2-5	80
58	Solanaceae	<i>Solanum nigrum</i>	Mako	H	M	WP	2-5	160
59	Solanaceae	<i>Withania coagulans</i>	Paneer dodi	H	M	F/S	2-5	167
60	Zingiberaceae	<i>Elettaria cardamomum</i>	Ilaechi sabz	H	Sp	S	0.5-1	105
61	Zingiberaceae	<i>Zingiber officinale</i>	Adrak	H	Sp & M	Rz	2-5	92
62	Zygophyllaceae	<i>Fagonia arabica</i>	Dhamasa	H	M	WP	5-10	22
63	Zygophyllaceae	<i>Tribulus terrestris</i>	Gokhro	H	M	F/S & L/St	5-15	28

Habit abbreviations: H = Herb, G = Grass, Sh = Shrub, T = Tree, Vi = Vine.

Class abbreviations: C = Culinary, DF = Dry fruit, Fr = Fruit, M = Medicine, Sp = Spice, Sc = Sugar crop, Ve = Vegetable, Os = Oilseed.

Part used abbreviations: B = Bulb, Bk = Bark, FJ = Fermented juice, Fl = Flower, F = Fruit, Gl = Gel, G = Gum, Hk = Husk, J = Juice, L = Leaves, O = Oil, P = Pulp, Rz = Rhizome, R = Root, RB = Root bark, S = Seed, St = Stem, UP = Unripe pulp, WP = Whole plant, W = Wood.

**Figure 2.** Medicinal plant habit used for heat stress management in small ruminants

Plant Part Used

Figure 4 illustrates that seeds were the most commonly used part (28.6%, n = 18), followed by leaves and stems (23.8%, n = 15), fruits (12.7%, n = 8), whole plants (11.1%, n = 7), roots and flowers (5% each), pulp, juice, extract, and gel (3% each), and rhizomes, bulbs, oils, gums, bark, and wood (1–2% each).

Route of Administration

The majority of natural elements (97%) were administered orally, while only 5% were applied topically (Figure 5). Topical applications included Fuller's earth, *Aloe vera* gel, and sandalwood for sunburn, skin inflammation, and epistaxis.

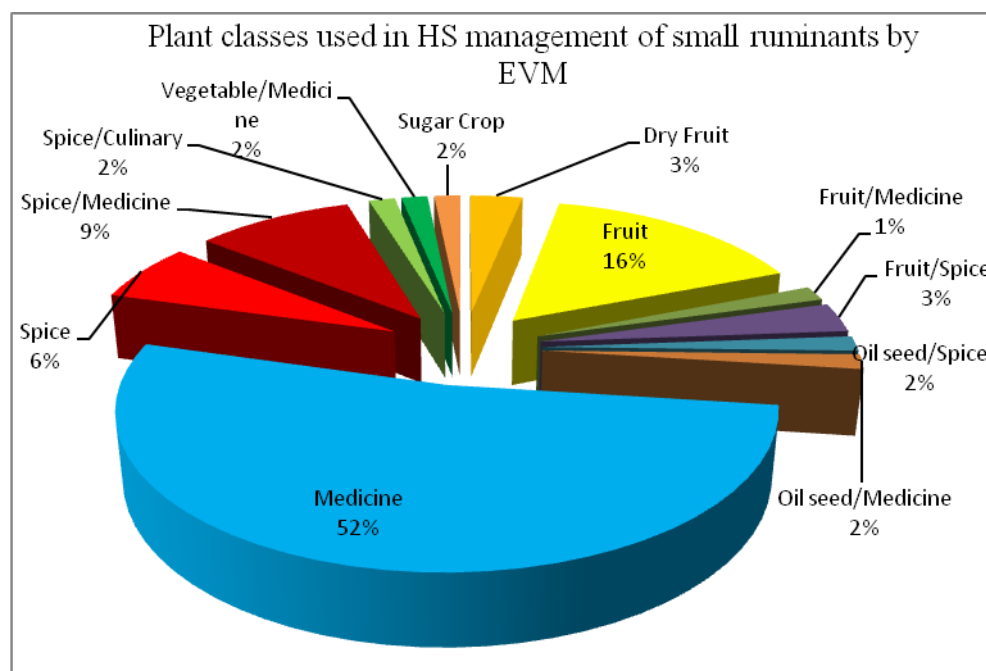


Figure 3. Plant classes used for heat stress management in small ruminants.

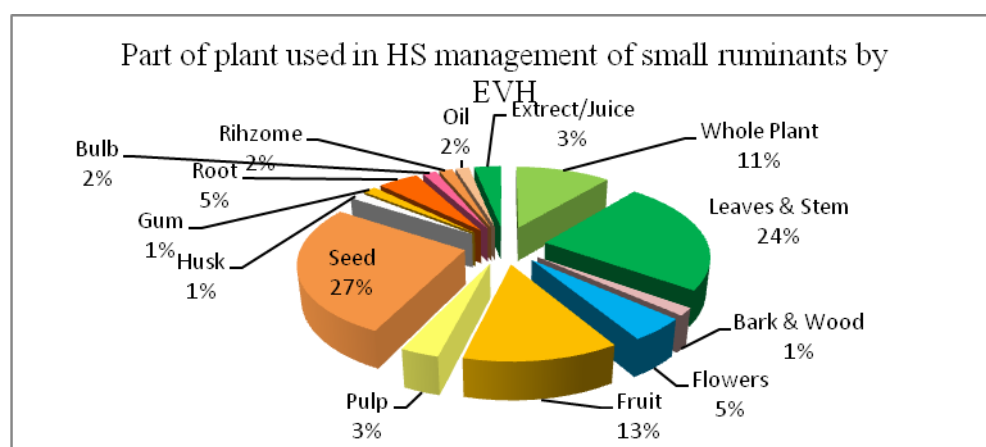


Figure 4. Plant parts used for heat stress management in small ruminants.

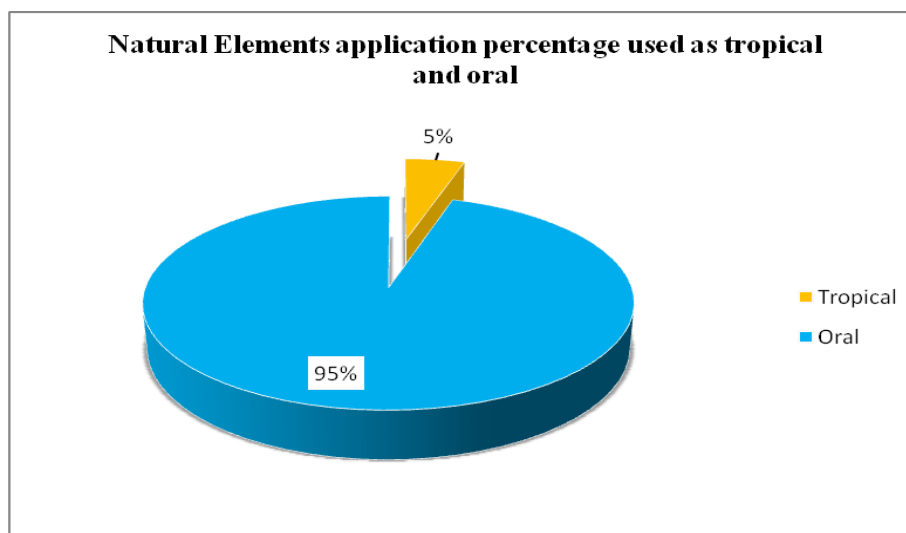


Figure 5. Percentage of natural elements applied topically vs. orally.

Discussion

Increasing ambient temperatures and more frequent heat waves threaten livestock productivity, health, and welfare, particularly in subtropical and arid regions (Chauhan et al. 2021; Habeeb et al. 2018; Karthik et al. 2021). Although small ruminants are relatively heat tolerant (Berihulay et al. 2019), prolonged heat exposure causes physiological and metabolic stress, reducing growth, reproductive performance, and immunity while increasing mortality. This ethnoveterinary survey shows that traditional livestock caretakers employ locally developed practices and biological resources to mitigate heat stress (Shoaib et al. 2021).

While the farmers and healers consistently reported positive outcomes such as reduced panting and improved appetite following administration of these remedies, these claims remain subjective and lack quantitative biometric and hematological verification through controlled farm trials. The socio-demographic profile showed that most respondents (85%) were aged 16–45 years, indicating active preservation of ethnoveterinary knowledge among the productive rural population (Mirani et al. 2014a). Low education levels (42% primary and 38% illiterate) suggest reliance on traditional and experiential learning (Aziz et al. 2018). Moreover, 70% had 5–35 years of livestock experience, highlighting their familiarity with heat-stress adaptation strategies.

The survey revealed a strong dependence on plant-based remedies (86.1%), followed by mineral (8.3%) and animal-derived sources (5.6%) (Figure 1). Fermented dairy products, particularly yogurt (57%) and buttermilk (95%), were commonly used during summer to improve hydration, rumen function, antioxidant status, and body-temperature regulation (Kalyan et al. 2014; Stobiecka et al. 2022). Farmers reported improved feed intake, reduced panting, and greater animal comfort. Common mineral remedies included pink salt (57%), black salt (43%), and potassium carbonate (17%), reflecting indigenous knowledge of electrolyte balance (Singh et al. 2021). Plant-based products such as jaggery, vegetable oils, and vinegar were also frequently used. Jaggery provided rapid energy, oils increased dietary energy density with minimal metabolic heat production, while vinegar was believed to support cooling, electrolyte balance, and gut health.

Fruit-based remedies, including lemon juice, tamarind pulp, and raw mango, were commonly used for their cooling and electrolyte-replenishing properties (Shah et al. 2023; Shoaib et al. 2021). Farmers reported reduced fatigue and hypersalivation and improved rumination during heat stress (Lebaka et al. 2021; Mengyuan et al. 2021). Effective herbal remedies included chicory seeds, mint leaves, *Aloe vera*, and *Polygonum bistorta* root, which were associated with improved thermoregulation, antioxidant and anti-inflammatory activity, and digestive health.

A total of 63 medicinal plant species from 36 families were documented, with Fabaceae being dominant, followed by Cucurbitaceae and Rosaceae, reflecting extensive botanical knowledge among local healers. Most remedies were herbs (43%), followed by trees (22%) and shrubs (17%), likely due to their availability and bioactive compounds. Seeds were the most frequently used plant part (28.6%), followed by leaves and stems (23.8%) and fruits (12.7%) (Figure 3). Most remedies were administered orally (95%) to support systemic thermoregulation and metabolism (Figure 4). Topical applications (5%) were mainly used for sunburn, skin inflammation, and epistaxis.

The predominance of botanical remedies (86.1%) reflects their accessibility, affordability, cultural familiarity, and intergenerational transmission. Several Fabaceae species, including *Tamarindus indica*, *Dalbergia sissoo*, and *Astragalus gummifer*, provide cooling, electrolyte balance, and metabolic support. Cucurbitaceous fruits, such as watermelon and muskmelon, aid hydration and thermoregulation through their high water and mineral

content. Species including *Saccharum officinarum*, *Polygonum bistorta*, *Grewia asiatica*, *Mentha* spp., and *Cichorium intybus* are valued for cooling, energy provision, detoxification, and digestive benefits. The high proportion of herbs (43%) reflects their abundance, rapid growth, and rich phenolic and flavonoid content (Mirani et al. 2014b; Titus 2022).

Heat stress in small ruminants causes hyperthermia, respiratory alkalosis, oxidative stress, reduced feed intake, endocrine disruption, and immunosuppression, compromising productivity and welfare (De 2022). The documented ethnoveterinary practices target these pathways using plants with diverse therapeutic properties. Phytochemical compounds may enhance antioxidant defense, regulate inflammation, and support metabolic stability during heat stress (Brown et al. 2019).

Functional classification showed that 52% of species were primarily medicinal, consistent with global ethnoveterinary records (Kuralkar & Kuralkar 2021). Many species had dual roles, such as spice/medicine, fruit/medicine, and oilseed/medicine, reflecting a food–medicine continuum (Wu & Liang 2018). During heat stress, fruits and oilseeds provide energy, micronutrients, and antioxidants that counteract reactive oxygen species (ROS) (Martinello et al. 2006). Antioxidants may therefore reduce oxidative damage, preserve cellular integrity, and support immune function during thermal stress.

The preference for seeds (28.6%) may reflect their high content of essential oils, tocopherols, and bioactive lipids (Medhat et al. 2025). Leaves and stems contain flavonoids and chlorophyll derivatives that contribute to antioxidant activity (Zeineldin et al. 2018). The frequent use of renewable plant parts also supports sustainable harvesting. Antioxidant-rich herbs and spices may help counteract reactive oxygen species and inflammation, while fruits and oilseeds provide hydration, electrolytes, and nutrients (Erucar et al. 2023). Herbal supplementation in sheep and goats may improve antioxidant and immune responses during heat stress, which disrupts antioxidant balance and increases cellular stress (Akbarian et al. 2016).

The ethnoveterinary data from 73 natural sources indicate an integrated approach combining herbal, mineral, and animal-derived materials to mitigate heat stress (Singh et al. 2025). Cooling species such as *Citrus limon*, *Coriandrum sativum*, *Mentha spicata*, and *Tamarindus indica* are commonly prepared as syrups or cooling infusions, providing organic acids and antioxidant compounds (Mishra et al. 2015; Kuralkar & Kuralkar 2021). Roots and bark of *Withania somnifera*, *Azadirachta indica*, and *Acacia nilotica* are used in decoctions for their tannins, flavonoids, and anti-inflammatory properties (Odhaib et al. 2021). Softer aerial parts, including *Ocimum basilicum* and *Foeniculum vulgare*, are prepared as infusions to preserve volatile oils (Erucar et al. 2023). Dosage varied according to plant part, generally ranging from 0.5–20 g, with fruits and pulps administered in larger quantities because of their high water content. This variation reflects empirical knowledge of plant chemistry and bioactive compound concentration (Geneva 2000; Parikh & Kothari 2016; Sahoo & Sharma 2023; Anand et al. 2025).

Future studies should incorporate phytochemical characterization, in vitro antioxidant and anti-inflammatory testing, and controlled in vivo experiments measuring oxidative stress biomarkers, immune response, and performance indices. Multi-omics approaches could further elucidate mechanisms of plant-mediated heat stress resilience.

Conclusions

This study highlights the widespread use of natural medicines by ethnoveterinary healers for managing heat stress in small ruminants. Botanical products dominated (86.1%), followed by mineral (8.3%) and animal sources (5.6%). A total of 73 natural items, including 63 medicinal plant species from 36 families, were documented, reflecting high ethnobotanical diversity. The predominant families (Fabaceae, Cucurbitaceae, Rosaceae, Apiaceae, Lamiaceae, and Solanaceae) are valued for cooling, hydration, antioxidant, and metabolic regulation properties. Practical responses to dehydration and thermal imbalance included fermented animal products (buttermilk, yogurt) and electrolyte-rich minerals (pink salt, black salt). Ethnoveterinary practices are cost-effective, locally available, and culturally accepted strategies for heat stress management. However, the reported efficacy is based on traditional knowledge and farmers' observations rather than controlled experimental evidence. While these traditional remedies support livestock productivity under harsh climates and provide a foundation for climate-resilient animal health systems, we strongly recommend that future studies conduct phytochemical profiling, in-vitro antioxidant assays, and controlled in-vivo feeding trials to scientifically verify the efficacy and safety of these traditional remedies before they are formally recommended as standard livestock management protocols.

References

- 1) Akbarian A, Michiels J, Degroote J, Majdeddin M, Golian A, De Smet S, 2016. Association between heat stress and oxidative stress in poultry; mitochondrial dysfunction and dietary interventions with phytochemicals. *Journal of Animal Science and Biotechnology* 7: 37. doi:10.1186/s40104-016-0097-5

- 2) Anand U, Tudu CK, Nandy S, Sunita K, Tripathi V, Loake GJ, Dey A, Proćków J, 2025. Ethnopharmacological potential of natural gums and mucilages: A comprehensive review. *Journal of Ethnopharmacology* 319: 117171. doi:10.1016/j.jep.2023.117171
- 3) Aziz MA, Adnan M, Khan AH, Shah AH, 2018. Ethnoveterinary medicinal plants used for treating livestock in northern Pakistan. *Journal of Animal and Plant Sciences* 28: 1554-1567.
- 4) Belhadj Slimen I, Najar T, Ghram A, Abdrrabba M, 2016. Heat stress effects on livestock: Molecular, cellular and metabolic aspects. *Journal of Animal Science* 94: 1-17. doi:10.2527/jas.2015-9757
- 5) Berihulay H, Abied A, He X, Jiang L, Ma Y, 2019. Adaptation mechanisms of small ruminants to environmental heat stress. *Animals* 9: 75. doi:10.3390/ani9030075
- 6) Bettencourt EMV, Tilman M, Narciso V, Carvalho MLS, Henriques PDS, 2013. The role of small ruminants in rural development: A review. *Small Ruminant Research* 114: 165-175. doi:10.1016/j.smallrumres.2013.06.005
- 7) Brown D, Muthukumar T, Karthik D, 2019. Phytochemicals as potential feed additives for heat-stressed ruminants. *Tropical Animal Health and Production* 51: 1063-1072. doi:10.1007/s11250-019-01823-5
- 8) Buttar HS, Kaur R, Kaur S, 2022. Aloe vera: A potential herbal adaptogen for heat stress management in livestock. *Veterinary World* 15: 1120-1128. doi:10.14202/vetworld.2022.1120-1128
- 9) Chauhan SS, Celi P, Leury BJ, Clarke IJ, Dunshea FR, 2016. Dietary antioxidants at supranutritional levels improve oxidative status and reduce the negative effects of heat stress in sheep. *Journal of Animal Science* 94: 3364-3374. doi:10.2527/jas.2016-0322
- 10) Chauhan SS, Dunshea FR, Leury BJ, 2021. Heat stress impacts on livestock production and its mitigation strategies. *International Journal of Biometeorology* 65: 1-13. doi:10.1007/s00484-020-02052-8
- 11) De K, 2022. Heat stress in small ruminants: Pathophysiology and mitigation strategies. *Small Ruminant Research* 212: 106712. doi:10.1016/j.smallrumres.2022.106712
- 12) dos Santos AC, de Sousa JER, de Araújo GGL, de Oliveira JS, 2021. Thermoregulatory responses and heat stress tolerance in small ruminants: A review. *Journal of Thermal Biology* 99: 102998. doi:10.1016/j.jtherbio.2021.102998
- 13) Erucar S, Misir S, Ozturk M, 2023. Essential oils and herbal extracts as feed additives for heat-stressed ruminants. *Journal of Essential Oil Research* 35: 123-135. doi:10.1080/10412905.2023.2184434
- 14) Galav P, Jain A, Katewa SS, 2010. Ethnoveterinary medicine used by the tribal people of Rajasthan. *Indian Journal of Traditional Knowledge* 9: 241-245.
- 15) Geneva, 2000. WHO Monographs on Selected Medicinal Plants. World Health Organization, Geneva, Switzerland.
- 16) Habeeb AA, Gad AE, Atta MA, 2018. Temperature-humidity index as a measure of heat stress in farm animals. *Journal of Animal Science and Technology* 60: 1-10. doi:10.1186/s40781-018-0184-y
- 17) Hashem NM, Gonzalez-Bulnes A, Simal-Gandara J, 2023. Climate change and small ruminant production: Challenges and opportunities. *Animals* 13: 335. doi:10.3390/ani13030335
- 18) Inbaraj S, Sejian V, Bagath M, Bhatta R, 2016. Impact of heat stress on immune responses of livestock: A review. *Journal of Agrometeorology* 18: 185-193. doi:10.54386/jam.v18i2.920
- 19) Jahan N, Ahmad M, Zafar M, 2015. Ethnobotanical uses of *Polygonum bistorta* in Pakistan. *Pakistan Journal of Botany* 47: 225-230.
- 20) Kalyan R, Kaur H, Singh S, 2014. Traditional dairy products in heat stress management. *Indian Journal of Dairy Science* 67: 1-6.
- 21) Karthik D, Suresh J, Kumar R, 2021. Climate change and livestock production: A review. *Journal of Climate Change* 7: 45-58. doi:10.3233/JCC-210005
- 22) Khalid A, Hamed R, Sultana N, Khan R, 2025. Spatiotemporal trends in heatwave events over Pakistan since 1980. *Climate Services* 37: 100425. doi:10.1016/j.cliser.2024.100425
- 23) Kuralkar P, Kuralkar SV, 2021. Role of herbal products in animal production: A review. *Veterinary World* 14: 1375-1383. doi:10.14202/vetworld.2021.1375-1383
- 24) Lacetera N, 2019. Impact of climate change on animal health and welfare. *Animal Frontiers* 9: 26-31. doi:10.1093/af/vfy032
- 25) Lebaka VR, Wee YJ, Ye W, 2021. Nutritional and health benefits of citrus fruits. *Food Science and Biotechnology* 30: 1-18. doi:10.1007/s10068-020-00856-6
- 26) Mahjoubi E, Yazdi MH, Aghaziarati N, Hossein Yazdi M, 2015. Heat stress and livestock productivity: A review. *Journal of Animal Science and Technology* 57: 1-8. doi:10.1186/s40781-015-0073-8
- 27) Martin GJ, 1995. *Ethnobotany: A Methods Manual*. Chapman and Hall, London, UK.
- 28) Martinello M, Lemos MA, Silva MV, 2006. Antioxidant activity of oilseeds in animal nutrition. *Animal Feed Science and Technology* 128: 123-135. doi:10.1016/j.anifeedsci.2005.12.005

- 29) Matei F, Popa M, Tofană M, 2020. Vinegar as a functional feed additive in livestock. *Journal of Food Processing and Preservation* 44: e14892. doi:10.1111/jfpp.14892
- 30) Medhat D, El-Sayed YS, Abdel-Daim MM, 2025. Bioactive lipids and tocopherols in seeds for oxidative stress mitigation. *Journal of Agricultural and Food Chemistry* 73: 234-245. doi:10.1021/acs.jafc.4c07890
- 31) Mengyuan L, Xiaojing L, Hai L, 2021. Fruit-based electrolytes for heat-stressed animals. *Animal Nutrition* 7: 456-463. doi:10.1016/j.aninu.2021.01.004
- 32) Mirani AH, Sial MA, Memon AQ, 2014a. Indigenous knowledge of livestock health management in rural Sindh, Pakistan. *Pakistan Journal of Agricultural Research* 27: 234-242.
- 33) Mirani AH, Sial MA, Memon AQ, 2014b. Ethnobotanical survey of medicinal plants used for livestock in Sindh. *Journal of Ethnobiology and Ethnomedicine* 10: 55. doi:10.1186/1746-4269-10-55
- 34) Mishra DP, Sahu RK, Mishra N, Behera AK, 2015. Herbal treatment for common diseases in ruminants: an overview. *Journal of Livestock Science* 6:36-43
- 35) Odhaib KJ, Ahmadi F, Soleimani AF, 2021. Tannins and flavonoids from medicinal plants in ruminant nutrition. *Journal of Applied Animal Research* 49: 1-12. doi:10.1080/09712119.2021.1981926
- 36) Parikh PK, Kothari CS, 2016. *Plantago ovata*: A review of its pharmacology and therapeutic potential. *Journal of Natural Remedies* 16: 1-12.
- 37) Sahoo A, Sharma D, 2023. Hydrating fruits in heat stress management of livestock. *Tropical Animal Health and Production* 55: 89. doi:10.1007/s11250-023-03512-2
- 38) Shah AH, Adnan M, Aziz MA, 2023. Traditional fruit-based syrups for livestock in South Asia. *Journal of Animal and Plant Sciences* 33: 456-465.
- 39) Sher H, Alyemeni MN, 2011. Ethnobotanical and phytochemical evaluation of *Rheum emodi*. *African Journal of Plant Science* 5: 234-240.
- 40) Shinde AK, Sejian V, 2013. Heat stress and small ruminant production in tropical countries: A review. *Journal of Agrometeorology* 15: 1-8. doi:10.54386/jam.v15i1.1418
- 41) Shoaib M, Mahmood A, Rashid S, 2021. Traditional veterinary practices in the Indus River basin: A historical perspective. *Journal of Ethnobiology and Ethnomedicine* 17: 45. doi:10.1186/s13002-021-00472-9
- 42) Singh AK, Kumar S, Singh R, 2025. Integrative ethnoveterinary medicine for heat stress in small ruminants. *Veterinary Medicine and Science* 11: e1456. doi:10.1002/vms3.1456
- 43) Singh SV, Singh RS, Singh M, 2021. Mineral supplementation in heat-stressed livestock. *Indian Journal of Animal Sciences* 91: 567-574. doi:10.56093/ijans.v91i7.115983
- 44) Slimen IB, Najjar T, Ghram A, Dabbebi H, Ben Mrad M, Abdrabba M, 2014. Reactive oxygen species, heat stress and oxidative-induced mitochondrial damage. *Journal of Thermal Biology* 44: 36-45. doi:10.1016/j.jtherbio.2014.06.009
- 45) Stobiecka M, Król J, Brodziak A, 2022. Fermented dairy products in animal nutrition. *Animals* 12: 345. doi:10.3390/ani12030345
- 46) Titus A, 2022. Phytochemical diversity in herbaceous medicinal plants. *Journal of Medicinal Plants Research* 16: 78-89. doi:10.5897/JMPR2022.7245
- 47) Torbat Esfahani MH, Niazi A, Afshar M, 2024. Strategies for heat stress management in small ruminants under arid and semi-arid conditions. *Veterinary Medicine and Science* 10: e1324. doi:10.1002/vms3.1324
- 48) Vaarst M, Alrøe HF, 2012. Ethnoveterinary knowledge as a basis for sustainable livestock farming. *Journal of Agricultural and Environmental Ethics* 25: 759-780. doi:10.1007/s10806-011-9349-1
- 49) Wu Y, Liang H, 2018. Food-medicine continuum in traditional Chinese medicine. *Journal of Ethnopharmacology* 210: 1-10. doi:10.1016/j.jep.2017.08.022
- 50) Zahoor Husain S, Malik RN, Javaid M, 2008. Ethnobotanical properties of *Dalbergia sissoo*. *Pakistan Journal of Botany* 40: 183-190.
- 51) Zeineldin M, Anele UY, Abdelaziz MA, 2018. Phytogenic compounds in livestock nutrition under heat stress. *Journal of Thermal Biology* 74: 1-10. doi:10.1016/j.jtherbio.2018.03.008
- 52) Zhang M, Dunshea FR, Warner RD, DiGiacomo K, Osei-Amponsah R, Chauhan SS, 2021. Impacts of heat stress on meat quality and strategies for amelioration: A review. *International Journal of Biometeorology* 65: 1-14. doi:10.1007/s00484-020-02048-4
- 53) Zhou H, Wang C, Ye J, Chen H, Tao R, 2019. Medicinal plants as potential feed additives for heat-stressed ruminants: A review. *Tropical Animal Health and Production* 51: 1073-1083. doi:10.1007/s11250-019-01861-5