

Review Article

Avicenna's foundations of traditional pharmacy and drug knowledge

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Abstract

Objective: Traditional pharmacy has its roots in ancient civilizations and it has been a fundamental pillar of traditional medicine throughout human history. Iran, with its rich ancient heritage, has made significant contributions to the development and expansion of pharmaceutical knowledge. This study aims to elucidate Avicenna (980–1037 AD) understanding of pharmaceuticals based on his Canon of Medicine.

Materials and Methods: The research involved an extensive examination of the text, where relevant keywords were systematically searched to retrieve and document pertinent data.

Results: Analysis of the Canon of Medicine, a seminal Persian medical text, reveals a sophisticated system of drug classification based on multiple criteria, including origin, composition, therapeutic effects, administration methods, temperament, dosage form, mode of action, application, nature, and grade. The naming of compound drugs follows specific principles, often referring to the drug category, constituent ingredients, targeted disease or body part, pharmacological action, Drug characteristics (temperament, color, or taste), origin, usage status, or synonyms. The text also provides detailed information on measurement units and tools used in drug preparation, offering valuable insights into the pharmaceutical practices of the medieval period.

Conclusion: This analysis highlights Avicenna's profound understanding of pharmaceutical principles. His systematic approach to drug classification, nomenclature, measurement systems, and pharmaceutical tools contributes significantly to the historical evolution of pharmacy and drug therapy.

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Introduction

Traditional pharmacy, as an essential branch of traditional medicine, has deep roots in ancient civilizations. Among them, Iran—with its rich historical and cultural heritage—has played a key role in the development and advancement of pharmaceutical knowledge. Although the origins of medicine and pharmacy are historically intertwined, a distinct separation between drug preparation and clinical treatment can be traced back over 4,000 years (Anderson 2005; Safari *et al.* 2020).

The earliest references to pharmacy and medicine in ancient Persia are found in the *Avesta*, the sacred Zoroastrian text. In the *Vendidad* section of the *Avesta*, pharmacists were referred to as *urvaro baešaza*, or “healers with plants” (Farsam 2009; Zargaran *et al.* 2013). Early Persians prepared complex pharmaceutical formulations such as *prahaoma*, a syrup derived from the *haoma* plant, whose main component is *Ephedra vulgaris* L.—a substance considered one of the earliest known natural stimulants and antidepressants.

Archaeological findings further confirm the extent of pharmaceutical knowledge in ancient Persia, revealing an array of medicinal tools from prehistoric and early historic periods (Zargaran *et al.* 2012). During the Sassanid era (224–637 AD), the Jundishapur Academy emerged as one of the most influential centers of medical learning in antiquity (Soleymani and Zargaran 2018). At this institution, Sābūr ibn Sahl (d. 869 AD, The year of Sābūr ibn Sahl's death.) compiled the *Qarabadin-e Kabir* in 869 AD, regarded by many as the world's first pharmacopeia (Sadeghi *et al.* 2020; Zargaran and Zarshenas 2017).

In the Islamic Golden Age, Iranian physicians and pharmacists continued to shape the medical sciences. (Tschanz 2003). Prominent figures such as Alī ibn Rabbān al-Ṭabarī (*Firdous al-Hikmah*), Rhazes (al-Ḥāwī fi al-Tibb or *Liber Continens*), and

‘Ali bin ‘Abaas Ahwāzi (al-Maleki or *Liber Pantegni*) discussed the nature, application, and effects of medications in clinical settings. Rhazes, notably, tested mercury laxatives on monkeys before prescribing them to humans, indicating a proto-experimental pharmacology (Majousi Ahwazi 2008; Rhazes 2001; Tabari 2002).

Among all these contributions, Avicenna (Ibn Sinā, 980–1037 AD) holds a distinguished place in the history of pharmacy (Mahdizadeh *et al.* 2015). His monumental work, *Al-Qanun fi al-Tibb* (The Canon of Medicine), became a foundational text in both Islamic and European medicine. Translated into Latin by Gerard of Cremona in the 12th century, the *Canon* was taught in European medical schools for nearly five centuries (Ghobadi Pour *et al.* 2019; Nasiri *et al.* 2023a; Nasiri *et al.* 2023b).

Avicenna devoted considerable attention to pharmacology, offering detailed discussions on drug composition, therapeutic properties, dosage forms, measurement systems, and pharmaceutical tools (Avicenna 2010). In recent decades, scholars have increasingly examined his methodologies, especially in relation to modern pharmacological principles (Amrollahi-Sharifabadi *et al.* 2024; Rahimi *et al.* 2017; Vaghebin *et al.* 2022).

This study aims to explore and clarify Avicenna's foundational concepts in pharmacy and drug knowledge. By analyzing traditional classifications, naming conventions, dosage measurements, and pharmaceutical preparations within his medical thought, this research offers a historical perspective on the evolution of pharmaceutical science in Persian medicine.

Materials and Methods

Given the historical nature of the topic, this descriptive and retrospective study analyzed Avicenna's Canon of Medicine using keyword-based textual analysis focused on drug classification,

nomenclature, dosage, and pharmaceutical tools. Relevant content was extracted and categorized. A supplementary literature review was also conducted in databases such as Scopus, PubMed, and Google Scholar. Thematic analysis was applied to both primary and secondary sources, and findings were organized accordingly.

Results

Avicenna's approach to drug classification in traditional pharmacy

In *Canon of Medicine*, Avicenna classifies drugs based on various criteria such as origin, composition, type of effect, method of administration, temperament, and dosage form, mode of action and application (Avicenna 2010). Each of these criteria plays a crucial role in understanding and utilizing drugs for disease treatment and health maintenance. Some of the most common classification categories are presented in Table 1.

Avicenna's principles for naming compound drugs

In *The Canon of Medicine*, the naming of compound drugs is based on specific principles and conventions. These naming rules offer insight into the composition, properties, and intended applications of each formulation. In some cases, the names clearly indicate the subject matter, while in others, they reveal it more implicitly (Avicenna 2010).

According to Avicenna, the main criteria used in naming compound drugs include:

Drug category

Names of constituent ingredients (either single or double components)

Target disease, affected body part, or associated symptoms

Therapeutic action or pharmacological property

Drug characteristics such as temperament, color, or taste

Names of individuals or books (referring to either the drug's inventor or the source of the prescription)

Conditions or method of administration

Alternative names or synonyms

Further examples of these conventions are presented in Table 2

Avicenna's system of measurement units in pharmaceutical practice

Avicenna employed a variety of units to measure medicinal substances (Avicenna 2010). Some of these weight units were frequently used throughout the *Canon of Medicine*, particularly in pharmaceutical formulations (Table 3).

1. Light Weights: *al-qīrāṭ* (0.2–0.3 g) and *dāniq* (0.6 g)

2. Medium Weights: *ḥabbah* (3.9 g) and *misqāl* (3.48 g)

3. Heavy Weights: *ūqīyah* (37.5 g) and *riṭl* (450 g)

Avicenna meticulously determined the quantities of each ingredient in compound formulations. For instance, in a prescription for *safūf*—a finely ground and sifted powder placed on the tongue and swallowed—used to treat liver pain and jaundice, he writes:

“*In this medical formula, one misqāl of washed tragacanth gum (Astragalus tragacantha), two dirhams of tabasheer (Bambusa arundinacea), one dirham of saffron (Crocus sativus), one and a half dāniqs of Chinese rhubarb (Rheum palmatum), and one dāniq of camphor (Cinnamomum camphora) are prescribed to be taken in a two-dirham dose with a decoction of plums (Prunus domestica) and half a riṭl of tamarind water (Tamarindus indica)*”.

Table 1. Drug classification according to Avicenna's Canon of Medicine

No	Topic	classification	Description	Example (Canon of Medicine)	References
1	origin	Herbal medicines	These types of medications are extracted from various parts of plants, such as roots, leaves, flowers, and fruits, and are often consumed as extracts, tablets, or capsules	Bābūnaj (<i>Anthemis nobilis</i> L.), mastaki (<i>Pistacia lentiscus</i> L.), ful-ful (<i>Piper nigrum</i> L.), ahlilaj (<i>Terminalia chebula</i>), zanjabīl (<i>Zingiber officinale</i>)	(Naseri et al. 2012)
		Animal medicines	These medications are derived from animal parts, including meat, bones, and skin	lamb meat, chicken fat, pigeon droppings,	Nafīsi 1939; Shams) (Ardakani 2006
		mineral medicines	These medications are prepared from minerals such as iron, zinc, calcium, and magnesium	Gūgard (sulfur), zarnīx (arsenic), mercury, lime	(Afsharipoor et al. 2013)
2	composition	Simple drugs	They are composed of a single plant or substance	cow's milk, pearl, sudāb (<i>Ruta graveolens</i>)	(Naseri et al. 2012)
		Compound drugs	They are derived from a combination of several different plants or substances	ma' jūn-e belādor, noqo' (Soaking any dry fruit in water) -e zerešk, animal antidote	(Naseri et al. 2012)
3	type of effect	Moghavvi	Strengthens the body	rose oil	(Naseri et al. 2012)
		Moltef	To soften and purify the blood	Hāshā (<i>Cordothymus capitatus</i> L.), zofā (<i>Hyssopus officinalis</i>), Bābūnaj (<i>Anthemis nobilis</i> L.)	Naseri et al. 2012;) (Shams Ardakani 2006
		Mofteh	To open passages and remove obstructions	Farāasion (<i>Marrubium vulgare</i> L.) va Bābūnaj oil	Naseri et al. 2012;) (Shams Ardakani 2006
		Mobred	Cooler	Al-kāfūr (<i>Laurus camphora</i>)	Naseri et al. 2012;) (Shams Ardakani 2006
		Jali	To clear dampness	anzurut va ma-al-asal	(Naseri et al. 2012; Shams Ardakani 2006)
		Ghaabiz	To bind and retain substances in the body	fruit of abhal (<i>Juniperus sabina</i>) and Otraj (citron)	(Naseri et al. 2012; Shams Ardakani 2006)
4	Method of administration	Mojfeff	To dry and eliminate dampness	Sandrus (<i>Callitris quadrivalvis</i>) va abu khalsa	(Naseri et al. 2012; Shams Ardakani 2006)
		Oral medications	-	Tablets, syrups and decoctions	-
		Topical medications	-	Ointment, poultice, oil and drops	-
		Inhaled medications	-	Inhalation and spray	-
5	Temperament	Warm and dry	-	Zanjabīl (<i>Zingiber officinale</i>), Darčini (<i>Cinnamomum aromaticum</i> Nees.), ful-ful (<i>Piper nigrum</i> L.)	-
		Warm and wet	-	Z' afarān (<i>Crocus sativus</i>), Honey, tamr (<i>Phoenix dactylifera</i>)	-
		Cold and dry	-	ghubayrā (<i>Elaeagnus angustifolia</i> L.), al-simāq (<i>Rhus coriaria</i> L.)	-
		Cold and wet	-	al-khass (<i>Lactuca sativa</i> L.), qīthhā (<i>Cassia fistula</i> L.),	-
6	dosage form	Extract	In this method, fresh or dried plants are boiled in water. Then, the extract is distilled and consume	kuzbarah (<i>Coriandrum sativum</i> L.) extract, kāsnī (Cichorium intybus L.) extract	(Afsharipoor et al. 2013; Naseri et al. 2012)
		Powder (zerur)	The plants or medicinal substances are dried and then ground into a powder	zerur æsfer, zerur aqbar	(Afsharipoor et al. 2013; Naseri et al. 2012)
		Tablet	These medications are prepared from extracts or medicinal powders and placed in pills	ḥabb al-kāfūr, ḥabb al-'ūd	(Afsharipoor et al. 2013; Naseri et al. 2012)
		Ointment	These medications are prepared for topical use on the skin and are often made from plant extracts	qīrūṭī (a type of oily or waxy ointment)	(Afsharipoor et al. 2013; Naseri et al. 2012)

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Table 1. continued

7	mode of action	Specific drugs	-	Anti-cancer drug, anti-diabetic drug	-
		Non-specific drugs	-	Anti-inflammatory drug, pain reliever	-
8	Application and nature	Absolute food	a group of foods that could not only affect body's function and organs structure	al-ḥinṭāh (<i>Triticum vulgare</i>) and honeyed egg	Nasari et al. 2012;) (Shams Ardakani 2006
		Absolute medicine	Absolute medicine is equaled approximately with drug in current medicine	Zanjabīl (<i>Zingiber officinale</i>) and rāziyānaj (<i>Foeniculum vulgare Mill</i>)	Nasari et al. 2012;) (Shams Ardakani 2006
		Medicinal food	they can affect the body with their special temperament and change body's function with the help of their medicinal quality	al-khass (<i>Lactuca sativa</i> L.), qiththā (<i>Cassia fistula</i> L.), al-qara, (<i>Cucumis colocynthis</i> L.)	Nasari et al. 2012;) (Shams Ardakani 2006
		Food medicine	they impress the body with their special quality and change temperament of the body, and a little part of them can turn to energy	al-na' nā (<i>Mentha piperita</i> L.), al-thūm (<i>Allium sativum</i> L.), al-hindibā (<i>Cichorium intybus</i> L.)	Nasari et al. 2012;) (Shams Ardakani 2006
		poisons	Plant poisons	Al-Bīsh (<i>Aconitum ferox</i>), belādor (<i>Semecarpus anacardium</i> L.), šoukaran (<i>Conium maculatum</i>), Kharbaq Aswad (<i>Helleborus niger</i>), al-Ḥanṣal (<i>Citrullus colocynthis</i>)	-
			Mineral poisons Animal poisons	Zarnīkh, Isfīdāj , mordārsang al-jarrārah, al-'aqrab, al-zanābīr	- -
9	Degrees of drug powers	First degree	-	Kornob (<i>Brassica oleracea</i> L.)	-
		Second degree	-	Z'afarān (<i>Crocus sativus</i>), Ushnān (<i>Seidlitzia rosmarinus</i>)	-
		Third degree	-	Kabīkaj (<i>Ranunculus aquatics</i> L.), Kharbaq Aswad (<i>Helleborus niger</i>)	-
		Fourth degree	-	Māzarīyūn (<i>Verbascum thapsus</i> L.) , Farfīyūn (<i>Euphorbia resinifera</i>)	-

Table 2. Principles of compound drug naming according to Avicenna's Canon of Medicine

NO	Principles	Example (<i>Canon of Medicine</i>)
1	drug category	Ointment, Pill, Lubricant, Suppository, Poultice ¹ , Powder, decocted
2	the names of the constituent ingredients	single Ma'jūn halilaj (<i>Terminalia chebula</i>), ma'jūn ² al-thūm (<i>Allium sativum</i>), double Ma'jūn lisān al-'asāfir, ma'jūn athānāsiyā al-ṣughrā, ma'jūn al-milḥ al-hindī
3	the name of the disease or body parts or symptoms of the disease	Ma'jūn ṣudā, Dahn al-awjā ³
4	the action and property of the drug	Mulayyīn (Laxative) halīlah al-aṣfār (<i>Terminalia chebula</i>)
5	Temperament	al-sudhāb (<i>Ruta graveolens</i> L.) al-yābis, zayt (<i>Olea europaea</i>) bārid yābis
	Color	al-zāj al-aḥmar, al-kammūn al-aswad, al-kurunb al-abyaḍ, al-khashkhāsh al-aswad
	Taste	al-rummān (<i>Punica granatum</i>) al-ḥāmiḍ (Soured), al-rāsin (<i>Inula helenium</i>) al-murr (Bitters), al-lawz al-ḥulw (Sweet) (<i>Amygdalus communis</i>), al-samak al-māliḥ (pleasant)
	Geography	jawz rūmī (<i>Juglans regia</i>), qiththā' hindī (<i>Cucumis melo var. flexuosus</i>), al-shītaraj al-fārsī (<i>Lepidium latifolium</i>), Samgh-e Arabi (<i>Acacia arabica</i>), Tamar Hindi (<i>Tamarindus indica</i>), Tin-e Armani (<i>Ficus carica</i>), Halilaj Kabulī (<i>Terminalia chebula</i>)
	In terms of its usefulness or efficacy	al-dawā' mujarrab nāfi' (This medicine is tested and beneficial), hādhā al-nabāt 'azīman jiddan (This plant is very great/magnificent), huwa nāfi' bi-l-khāṣṣah (It is specifically/especially beneficial), huwa nafis jiddan (it is very precious)
	Size	al-jawz al-ṣaghīr, 'azīz al-kabīr, 'azīz al-ṣaghīr, al-qanṭūriyūn al-kabīr wa al-ṣaghīr, al-lablāb al-kabīr, dawā' al-lakk al-akbar
6	the names of people or books	some of the learned physicians have claimed that this medicine... Physicians call it "Lisan al-haml (<i>Plantago major</i>). Physicians also call it "Bazr al-banj (<i>Hyoscyamus albus</i>). This medicine (shiyāf al-gharb) is experienced by Ibn Zakaria (Abu Bakr Muhammad bin Zakariya Razi (251-313 AH; 865-925 CE) is one of the greatest physicians of the Islamic Golden Age (Aghabeiglooei <i>et al.</i> 2024)) It is one of the inventions of the people of India...
7	the status of drug use	The tried and tested powder, highly experimented with, is what some physicians have prescribed.
8	the other name of the drug (synonym)	The people of Tabaristan call it "kūbrīl": "inab al-tha'lab" (<i>Solanum nigrum</i>) The making of the confection known as "al-kindī". A confection attributed to Aristomachus. in Tabaristan it is called "baṭāḥik": "āzāddarakht" (<i>Melia azedarach</i>) The people of Iraq call it the "tree of bugs": (<i>Ulmus campestris</i>)

¹ A semi-solid topical drug preparation for ulcers and wounds that contains wax, oil, gum, or other mucilaginous drugs (Nafisi, 1939)

¹ Soft medicines pounded and mixed with honey are called potions (Nafisi, 1939)

¹ Avicenna Says that Dahn al-awjā medicine is one of the inventions of Indian sages, which is effective in treating most pains (Avicenna, 2010)

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Table 3. Medicine measurement units used in the Avicenna's Canon of Medicine

No	measurement units (<i>Canon of Medicine</i>)	Description	Modern equivalent	References
1	Misqāl	Another historical unit of weight, similar to the deram but can vary in size depending on the region.	5 grams	(Jorjani 2009)
2	ḥabbah	ḥabbah is a solid dosage form that can be taken as a pill or tablet	9.3 grams,	Ansari Shirazi) (1992)
3	juz'	A part or portion, often used to indicate a specific fraction of a dose	-	(Jorjani 2009)
4	dāniq	-	0.6 gram	Jalal Shokohi) (2018; Jorjani 2009)
5	'adad	Number, referring to the quantity or count of something	-	Jalal Shokohi) (2018; Jorjani 2009)
6	ūqīyah	An ūqīyahis	37.5 grams	(Jorjani 2009)
7	riṭl	riṭl is a unit of weight,	450 grams	(Naseri et al. 2012)
8	al-qīrāt	A al-qīrāt is a unit of weight	0.2-0.3 grams	Jalal Shokohi) (2018; Jorjani 2009)
9	Miqdār	Quantity or amount, indicating the overall dosage	-	Jalal Shokohi) (2018; Jorjani 2009)
10	mil'aqah	Mil'aqah, an traditional medicine unit of weight, means a "spoon". It holds four mithqāls of honey, and one mithqāl and one dirham of medicine.	-	(Avicenna 2010)
11	dirkhamī	A dirkhamī is six awthūlū ¹	5 grams	(Avicenna, 2010)
12	istār	.An istār is exactly four Misqāl	20 grams	(Avicenna, 2010)
13	qist	A qist is one and a half ratls plus one-sixth of a ratl, which is equivalent to 20 ūqīyahs.	750 grams	(Avicenna, 2010)
14	dawraq	A dawraq is three riṭls.	1350 grams	(Avicenna, 2010)
15	qūṭūlā	A qūṭūlā is equal to seven ūqīyahs.	262.5 grams	(Avicenna, 2010)
16	maṣṭarūn al-kabīr	three ūqīyahs	112.5 grams	(Avicenna, 2010)
17	maṣṭarūn al-ṣaghīr	six dirkhams	21 grams	(Avicenna, 2010)
18	uksūthāfan	equal to 18 dirkhams	63 grams	(Avicenna, 2010)
19	qawānūs	one and a half ūqīyahs	56.25 grams	(Avicenna, 2010)
20	bunduqah	one dirkham	3.5 grams	(Avicenna, 2010)
21	jawzah	14 shāmūns (or sāmūnā)	-	(Avicenna, 2010)
22	sukrujah	six and one-quarter istārs	125 grams	(Avicenna, 2010)
23	awthūlū	one and a half dāniqs	0.9 grams	(Avicenna, 2010)
24	Dirham	-	2.97-3.5 grams	(Jalal Shokohi, 2018)
25	Hams	One al-qīrāt	0.2-0.3 grams	(Avicenna, 2010)

¹ Unit of weight in traditional medicine

Avicenna's description of tools used in drug preparation and production

In earlier centuries, pharmaceutical processes were performed manually with the aid of traditional instruments. These devices comprised a range of tools and equipment employed in the preparation and manufacturing of medicines (Levey 1973; Savage-Smith 2008; Ullmann 1978). In Canon of Medicine, Avicenna provided

detailed accounts of the instruments utilized in the formulation and production of drugs. A general overview of these tools is presented in Table 4.

Each of these tools served a specific function. For instance, the retort and alembic (*al-Qara' wa al-Anbīq*) were used for distillation and for separating volatile substances from liquid mixtures, whereas crucibles (*būta*) were employed for heating

materials and melting metals. The "*al-Qara*" functioned as the boiling flask, while the "*al-Anbīq*" served as the condenser head; together, they formed a complete apparatus analogous to the modern Clevenger apparatus, which is specifically designed for the extraction of essential oils. A cylindrical tube (*unbūbah*) served as a vessel for measuring liquid volumes, while funnels (*al-qim*) facilitated the transfer of liquids into narrow-necked containers. Filters (*karbas*) were utilized to clarify liquids and remove impurities, flasks (*qomqomat*) substances and medicinal preparations, and mortars (*al-hāvan*) for grinding and pulverizing ingredients (Avicenna 2010). The systematic use of these instruments allowed traditional pharmacists to compound and manufacture a wide range of medicinal formulations with notable precision and craftsmanship.

One of the principal instruments in traditional pharmacy- and one that receives notable emphasis in Avicenna's Canon of Medicine, is the mortar (*al-hāvan*). This tool was essential for grinding spices, pulverizing raw medicinal materials, and blending multiple ingredients. Throughout the Canon of Medicine, Avicenna repeatedly references the mortar in the preparation of various remedies. For example, in a prescription for the treatment of gastric inflammation, he instructs: "*Combine the extract of myrtle leaves (*Myrtus communis*), burnt sandalwood (*Santalum album*), wax, rose oil (*Rosa damascene*), and apple (*Pyrus malus*) juice together in a mortar.*" Such examples throughout the text clearly demonstrate that the mortar was regarded as an indispensable tool in pharmaceutical practice.

Table 4. . Tools used in the preparation and production of drugs in the Avicenna's Canon of Medicine

No	Type	Name (Canon of Medicine)	Meaning	Definition	References
1	Containers	al-Qara'	Retort	A pumpkin-shaped container used for distilling liquids, distillation tools.	(Jorjani, 2009)
		al-Anbīq	Alembic	It is a container for distilling liquids and taking extract and sweat.	(Jorjani, 2009)
		Qomqomat	Flask	A copper bottle, especially one for holding a liquid.	(Jorjani, 2009)
		al-qim'	Funnel	A conical utensil for pouring liquid through a small opening	(Jorjani, 2009)
		Zujāj	Glass	vessel or container made of glass	(Jorjani, 2009)
2	Fabrics	Karbās	Coarse cloth	Coarse white cotton fabric	(Jorjani, 2009)
		Kharqha	Cloth	A piece of cloth or clothing	(Jorjani, 2009)
		Abrīsam	Silk	A very thin and strong web made by opening the silkworm cocoon	(Jorjani, 2009)
		Sūfīyah	Wool	The soft, hairy coat of a sheep, goat, or other animal.	(Jorjani, 2009)
3	Tools and Equipment	al-hāvan	Mortar	A mortar is a side of wood or iron in which medicines are pounded.	(Jorjani, 2009)
		Unbūbah	Cylinder	A narrow and long metal object in the shape of a tube	(Jorjani, 2009)
		Zarāqa	Syringe	A medical instrument used for injecting or withdrawing fluids.	(Jorjani, 2009)
		Fatīla	Cloth fabric	Cotton or woven fabric	(Jorjani, 2009)
		Kūra	Furnace	A structure in which heat is generated.	(Jorjani, 2009)
Salāya	Slab	the tool for grinding mineral substances	(Jorjani, 2009)		

Discussion

The present study sought to elucidate the foundational principles underlying drug classification, nomenclature, measurement systems, and pharmaceutical instruments as documented in Avicenna's seminal work,

The Canon of Medicine. The findings demonstrate that Avicenna proposed a sophisticated, multidimensional system for categorizing drugs based on origin, composition, temperament (*mizāj*), dosage form, route of administration, and pharmacological effects. In addition, the

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nomenclature of compound medicines follows clearly defined conventions, often derived from their constituent ingredients, associated diseases, pharmacodynamic properties, or even their inventors or textual sources. Avicenna also outlined a standardized hierarchy of weight-based measurement units- from light units such as *qīrāt* and *dāniq* to heavier ones like *ūqīyah* and *riṭl*- to ensure precision in pharmaceutical formulation. Moreover, the Canon of Medicine provides numerous references to manual tools used in drug preparation, reflecting the highly methodical nature of medieval pharmaceutical practice (Avicenna 2010).

A closer examination of Avicenna's drug classification system in the Canon of Medicine reveals an approach deeply rooted in the intellectual framework of 11th-century Persian Medicine, yet remarkably aligned with principles found in modern pharmaceutical science. His categorization of substances according to their origin- whether plant, mineral, or animal- mirrors the fundamental structure of contemporary pharmacognosy and the ongoing search for bioactive natural compounds (Camp et al. 2012; Tyler et al. 1988). Likewise, Avicenna's emphasis on the "type of effect" and "mode of action, though rooted in Galenic physiological theory, conceptually anticipates the core principles of modern pharmacodynamics (therapeutic effects and mechanisms at target sites) and pharmacokinetics (absorption, distribution, and duration of action) (Brunton et al. 2018). The concept of "temperament," firmly associated with classical humoral theory (Nimrouzi and Zarshenas 2017; Tafazoli et al. 2022; Tansaz et al. 2021), may be interpreted as an early recognition of individualized therapeutic response- an idea now formalized within the discipline of pharmacogenomics. Furthermore, Avicenna's categorization of drugs based on their "application" directly parallels the therapeutic classification systems used in contemporary medicine (Katzung et al.

2020), underscoring a longstanding continuity in organizing medicinal substances according to their clinical utility.

The naming principles of compound drugs in the Canon of Medicine—including classification by therapeutic category, active constituents, target organs, or pharmacological properties—demonstrate a structured system that closely parallels modern pharmacopoeial standards. The use of disease-oriented nomenclature (e.g. *Ma'jūn ṣudā* — "medicine for the treatment of headache") reflects an approach analogous to the Anatomical Therapeutic Chemical (ATC) classification employed in contemporary pharmacology. Likewise, ingredient-based designations (e.g. *ma'jūn al-thūm* — "soft preparations mixed with honey and garlic (*Allium sativum*)") correspond to current practices emphasizing active components in drug labeling (Heinrich et al. 2018; Morris et al. 2012).

Furthermore, Avicenna's detailed descriptions of drug temperament (e.g. hot/cold, dry/moist) and sensory properties such as taste (bitter, sweet, and astringent) — used to predict therapeutic suitability and patient tolerance, conceptually foreshadow modern pharmacokinetic considerations like oral bioavailability (influenced by solubility and gastrointestinal absorption) and patient adherence (affected by palatability and sensory acceptability) (Brunton et al. 2018). Although articulated within a pre-scientific paradigm, these historical conventions exhibit an empirical coherence consistent with evidence-based pharmacy—particularly within the field of ethnopharmacology where therapeutic development is informed by traditional medical knowledge (Heinrich et al. 2018). Thus, Avicenna's nomenclatural framework illustrates an early model of structured pharmacological taxonomy that bridges empirical observation with systematic classification.

In the Canon of Medicine, Avicenna employed a systematic hierarchy of weights—ranging from light to moderate and heavy units, such as *mithqāl*, *ūqīyah*, and *dāniq*—to ensure precision in drug quantification, reflecting an early form of pharmacopoeial standardization within Persian medicine (Levey 1973; Savage-Smith 1987). Although remarkably structured for its time, this measurement system does not match the scientific rigor of modern posology and bioequivalence standards, which rely on metric and molecular units such as micrograms, milligrams, and molar concentrations (Katzung et al. 2020). Nonetheless, the methodological approach of Iranian traditional pharmacy to dosage regulation laid an essential foundation for subsequent advancements in pharmacognosy and pharmaceutical formulation (Evans 2009).

From a modern pharmacological perspective, the lack of quantitative pharmacokinetic parameters such as volume of distribution (V^d), elimination half-life ($t_{1/2}$), and clearance in historical dosing systems inherently limited the precision of dose–response relationships, therapeutic index estimation, and systematic toxicity profiling (Shargel and Andrew 2015). Nevertheless, these traditional units hold considerable significance within the fields of historical pharmacy and ethnopharmacology (Jacquart 2008), as they reflect early attempts to standardize dosage and minimize adverse effects. Their examination offers valuable insight into the gradual transition from empirically derived Galenic dosages to contemporary evidence-based dosing protocols.

In the Canon of Medicine, Avicenna describes a range of sophisticated pharmaceutical instruments, such as the *retort* (*al-Qara'*) and *alembic* (*al-Anbīq*) for distillation, as well as the *mortar* (*al-hāwan*) and *slab* (*salāya*) for grinding and processing medicinal substances—illustrating the notable technological progress achieved within Islamic scientific

culture. Although these devices were simpler in structure compared to modern equipment such as cleavers, rotary evaporators, high-speed mixers, centrifuges or spectrophotometers, they established the foundational principles of drug processing and active compound purification. Contemporary techniques such as micronization for particle size reduction has advanced pharmaceutical processing beyond traditional mortar-and-pestle grinding methods; however, foundational practices like steam distillation for essential oil extraction and filtration using cloth media remain essential in modern pharmacognosy (Aulton and Taylor 2021; Thomas and David 2007).

The primary limitation of these early tools was their lack of precise control over physicochemical parameters such as temperature and pressure, which modern innovations—including automated distillation systems with programmable temperature controllers and high-pressure homogenizers for nanoformulation—have effectively overcome. Nonetheless, the instrumental foundations established by Persian scholars, such as the retort and alembic, served as critical precursors to contemporary scientifically optimized pharmaceutical manufacturing processes.

This study suggests that modern pharmaceutical science could benefit from a systematic reevaluation of historical Persian drug classification systems and measurement units through the lens of computational pharmacology and bioinformatics, potentially uncovering overlooked therapeutic correlations. In essence, Avicenna's Canon of Medicine represents a highly structured pre-modern pharmaceutical framework which—despite its technological constraints—anticipated many contemporary principles of drug standardization, nomenclature, and instrumentation. Its integration of humoral theory with precise material practices illustrates a pivotal transitional stage between Galenic empiricism and evidence-based pharmacy, offering valuable insights

for interdisciplinary research in ethnopharmacology, pharmaceutical history, and the broader evolution of medical science.

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Conflicts of interest

Authors state that there is not any conflict of interests.

Author contributions

The authors confirm their contribution to the paper as follows: Conceptualization, Supervision, Validation, Writing-Reviewing and Editing: Z.A and J.R.O and M.MA. Investigation, Resources, Writing-Reviewing and Editing: M.MA and A.A and J.R.O. Methodology, Software, Formal analysis, Writing- Reviewing and Editing: R.S and M.MA. and Z.A. Investigation: M.MO and Z.A. Conceptualization, Supervision, and Writing- Original draft preparation: Z.A and R.S and M.MO.

Ethical Approval

The present study with ethics ID of IR.MUBABOL.HRI.REC.1401.027 is approved by ethics committee of Babol university of medical sciences.

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