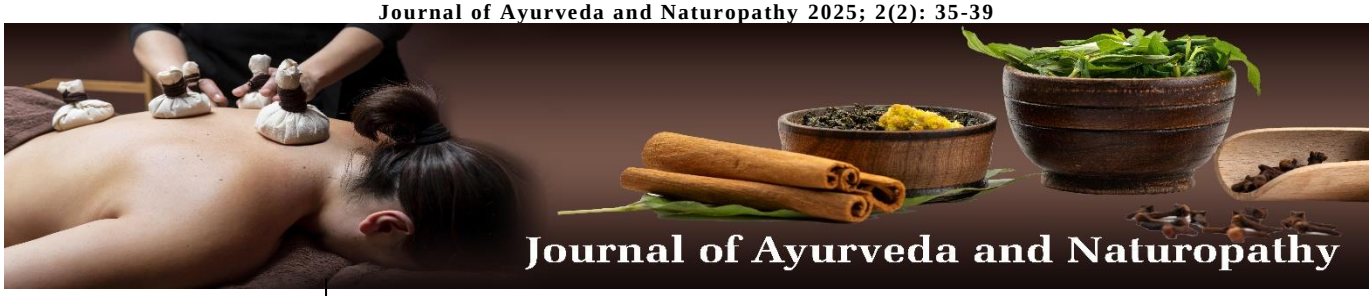

ISSN Print: 3078-6282
ISSN Online: 3078-6290
Impact Factor (RJIF): 5.48
JAN 2025; 2(2): 35-39
https://www.ayurvedjournal.net
Received: 23-05-2025
Accepted: 26-06-2025

Dr. Megh A Patel
PG Scholar, Department of Kriya Sharir, Himalaya Ayurvedic PG Medical College, Jeevanwala, Majri Grant, Via, Doiwala, Uttarakhand, India

Dr. Priya M Patki
Guide, Department of Kriya Sharir, Himalaya Ayurvedic PG Medical College, Jeevanwala, Majri Grant, Via, Doiwala, Uttarakhand, India

Dr. Kavya Kala
Co-Guide, Department of Kriya Sharir, Himalaya Ayurvedic PG Medical College, Jeevanwala, Majri Grant, Via, Doiwala, Uttarakhand, India

Corresponding Author:
Dr. Megh A Patel
PG Scholar, Department of Kriya Sharir, Himalaya Ayurvedic PG Medical College, Jeevanwala, Majri Grant, Via, Doiwala, Uttarakhand, India

Comprehensive review of *Agni* physiology: *Ayurvedic* perspectives and modern correlations

Megh A Patel, Priya M Patki and Kavya Kala

DOI: https://www.doi.org/10.33545/ayurveda.2025.v2.i2.A.28

Abstract
Background: *Agni*, a fundamental concept in *Ayurveda*, refers to the biological fire responsible for digestion, metabolism, and overall homeostasis. It plays a pivotal role in the maintenance of health by governing *Ahara Pachana* (digestion), *Dhatu Poshana* (nourishment of tissues), and *Ojas* formation (vital essence). Modern physiology describes metabolism through enzymatic, hormonal, and cellular mechanisms, yet parallels exist with *Ayurvedic* descriptions of *Agni*.
Objectives: To provide an in-depth analysis of *Agni* physiology from *Ayurvedic* texts and to establish its modern biomedical correlations. The review aims to elucidate the clinical significance of *Agni* in health and disease, and its relevance in contemporary biomedical science.
Methods: A comprehensive literature review was performed using classical *Ayurvedic* treatises including *Charaka Samhita*, *Sushruta Samhita*, and *Ashtanga Hridaya*, along with their commentaries. Modern scientific data were sourced from indexed journals, textbooks of physiology, biochemistry, and metabolism. Comparative analysis was carried out to correlate *Agni* types with metabolic functions, digestive enzymes, gastrointestinal physiology, and metabolic pathways.
Results: *Ayurveda* classifies *Agni* into *Jatharagni*, *Bhutagni*, and *Dhatvagni*, each responsible for successive stages of digestion and metabolism. *Jatharagni* aligns with gastric and pancreatic secretions, *Bhutagni* with nutrient assimilation and molecular transformations, and *Dhatvagni* with tissue-specific metabolism. Impaired *Agni* corresponds to metabolic syndromes, gastrointestinal disorders, and chronic inflammatory conditions in modern medicine. The modulation of *Agni* through diet, lifestyle, and therapeutics reflects the modern understanding of metabolic homeostasis and disease prevention.
Conclusion: The *Ayurvedic* concept of *Agni* provides a comprehensive, systemic understanding of digestion and metabolism, resonating with modern biomedical principles. Integrating *Agni* physiology with current metabolic science can enrich personalized medicine, preventive healthcare, and holistic management of metabolic disorders.

Keywords: *Agni*, *Jatharagni*, metabolism, digestive physiology, ayurveda, modern correlations

Introduction

The concept of *Agni* in *Ayurveda* is one of the most profound and pivotal principles governing human physiology. The term *Agni*, meaning fire, transcends its literal sense to represent all transformative processes in the body, including digestion, absorption, assimilation, and metabolism. Classical *Ayurvedic* texts like *Charaka Samhita*, *Sushruta Samhita*, and *Ashtanga Hridaya* place significant emphasis on *Agni* as the cornerstone of life, health, and longevity. The balance of *Agni* ensures proper nourishment of *Dhatus*, maintenance of vitality (*Ojas*), immunity, and overall well-being. Any impairment of *Agni* is considered the root cause of numerous diseases, emphasizing its critical role in *Ayurvedic* pathology and treatment paradigms [1].

In *Ayurveda*, *Agni* is not a single entity but a hierarchical system categorized into *Jatharagni*, *Bhutagni*, and *Dhatvagni*. *Jatharagni* is the primary digestive fire located in the gastrointestinal tract, particularly the stomach and duodenum, responsible for the digestion of ingested food. *Bhutagni* corresponds to the metabolic processing of the five *Mahabhutas* (elemental constituents) within the absorbed nutrients. *Dhatvagni*, on the other hand, refers to tissue-specific metabolic processes responsible for the transformation and nourishment of the seven *Dhatus* (body tissues). This multi-level conceptualization mirrors the layered complexity of human metabolism described in modern science [2].

Modern physiology provides a detailed understanding of digestion and metabolism through enzymatic activity, hormonal regulation, biochemical pathways, and cellular bioenergetics. The gastrointestinal system, supported by organs such as the liver, pancreas, and small intestine, performs the mechanical and chemical breakdown of food, mirroring the functions attributed to *Jatharagni*. At the molecular level, cellular respiration, anabolic and catabolic processes, and enzyme-substrate interactions exhibit functional similarities with the roles assigned to *Bhutagni* and *Dhatvagni*. This congruence allows for a meaningful dialogue between traditional *Ayurvedic* knowledge and contemporary biomedical science [3].

The physiological health of *Agni* is also intricately linked to the balance of *Tridosha—Vata*, *Pitta*, and *Kapha*. An optimal state of *Agni* is termed *Samagni*, ensuring balanced doshic functions and metabolic harmony. Variations like *Tikshnagni*, *Mandagni*, and *Vishamagni* reflect different patterns of metabolic disturbances akin to hypermetabolism, hypometabolism, and metabolic instability observed in various diseases. Understanding these variations aids in personalized diagnosis and tailored therapeutic interventions in *Ayurveda*, comparable to personalized medicine in modern healthcare. [4].

Clinically, the assessment of *Agni* is crucial in *Ayurveda* for determining digestive strength, nutritional status, metabolic health, and susceptibility to diseases. Therapeutic strategies focusing on *Agni* include dietary modifications (*Ahara*), lifestyle practices (*Vihara*), herbal formulations, *Panchakarma* procedures, and rejuvenation therapies (*Rasayana*). These interventions aim to restore and sustain *Agni*, thereby preventing and managing metabolic, gastrointestinal, and systemic disorders. Modern research increasingly recognizes the value of gut health, microbiota, and metabolic regulation, resonating with the *Ayurvedic* emphasis on *Agni* [5].

Therefore, a comprehensive review of *Agni* physiology not only reinforces its foundational importance in *Ayurveda* but also bridges the traditional wisdom with contemporary biomedical insights. Exploring these correlations enhances the scope of integrated medicine, offering novel perspectives for disease prevention, health promotion, and metabolic management. This review seeks to present a detailed understanding of *Agni* from both classical and modern viewpoints, highlighting its relevance in current healthcare practices [6].

Aim and objective

Aim: To comprehensively review the physiology of *Agni* in *Ayurveda* and establish its scientific correlations with modern digestive and metabolic physiology.

Objectives

1. To explore the types and functions of *Agni* as described in *Ayurvedic* texts.
2. To correlate *Jatharagni*, *Bhutagni*, and *Dhatvagni* with modern metabolic processes.
3. To assess the clinical significance of *Agni* in health and disease.
4. To identify the relevance of *Agni* modulation in modern preventive and therapeutic strategies.

Materia and Method

This review was conducted through an extensive literary exploration of classical *Ayurvedic* texts, including *Charaka Samhita*, *Sushruta Samhita*, *Ashtanga Hridaya*, and their authentic commentaries to understand the traditional conceptualization of *Agni*. Parallelly, contemporary scientific literature on human digestion, metabolism, enzymology, and gastrointestinal physiology was sourced from indexed journals, academic textbooks, and online research databases such as PubMed, Scopus, and Google Scholar. A comparative analytical approach was employed to systematically correlate the *Ayurvedic* classification of *Agni—Jatharagni*, *Bhutagni*, and *Dhatvagni*—with modern physiological and biochemical mechanisms, aiming to synthesize a cohesive understanding relevant to both traditional and modern medicine.

Conceptual study

In *Ayurveda*, the concept of *Agni* holds a central position in understanding human physiology, pathology, and therapeutics. *Agni*, literally meaning "fire," represents the biological power responsible for all transformative processes in the body, encompassing digestion, metabolism, absorption, assimilation, and cellular transformation. The equilibrium of *Agni* is vital for health, longevity, immunity, and well-being, while its imbalance is considered the root cause of all diseases (*Rogāḥ Sarvepi Mandāgnau - Charaka Samhita Chikitsa Sthana 15/3*) [7].

The term *Agni* is derived from the Sanskrit root "*Anj*" meaning to glow, burn, or digest. In the physiological context, *Agni* refers to the entity responsible for the digestive and metabolic activities at various levels of the body. It is the innate transformative force that governs the breakdown of food, energy production, tissue nourishment, and maintenance of homeostasis [8].

Types of Agni in Ayurveda

Ayurveda classifies *Agni* into different types based on their location, function, and specificity in the body:

Type of Agni	Number	Location	Function
Jatharagni	1	Stomach & Duodenum (*Amashaya, Grahani*)	Primary digestion of ingested food
Bhutagni	5	Liver, Cells	Metabolizing the essence of the five *Mahabhutas*
Dhatvagni	7	Each of the Seven *Dhatus*	Tissue-specific metabolism and nourishment

a) Jatharagni

Jatharagni is the central digestive fire located in the gastrointestinal tract, especially in the *Grahani* (duodenum and proximal small intestine). It initiates the primary digestion by breaking down ingested food into absorbable forms. *Jatharagni* is regulated by *Pachaka Pitta*, *Samana Vata*, and *Kledaka Kapha*, reflecting a balance of physiological elements that aid digestion.[9]

Jatharagni is further classified into four states based on doshic predominance:

- ***Samagni*:** Balanced, healthy digestive capacity.
- ***Vishamagni*:** Irregular digestion due to *Vata* dominance.
- ***Tikshnagni*:** Hyperactive digestion caused by *Pitta* predominance.
- ***Mandagni*:** Weak digestion attributed to *Kapha* dominance.

b) Bhutagni

After the primary digestion, nutrients undergo transformation by *Bhutagni*, which represents the metabolic processing of each of the five *Mahabhutas*:

1. *Prithvi Agni* (Earth element)
2. *Ap Agni* (Water element)
3. *Tejas Agni* (Fire element)
4. *Vayu Agni* (Air element)
5. *Akasha Agni* (Ether element)

Bhutagni ensures that the elemental composition of nutrients aligns with the needs of the body, contributing to the subtle biochemical transformations required for tissue building and energy synthesis.

c) Dhatvagni

Each of the seven *Dhatus* (*Rasa*, *Rakta*, *Mamsa*, *Meda*, *Asthi*, *Majja*, *Shukra*) possesses its own specific *Agni* known as *Dhatvagni*. This type of *Agni* is responsible for the metabolic processing and nourishment of each tissue. For instance:

- ***Rasadhatvagni*:** Converts *Rasa* to nourish *Rakta*.
- ***Raktadhatvagni*:** Facilitates conversion of *Rakta* to *Mamsa*.
- This sequential transformation continues until the formation of *Shukra Dhatu*.

This sequential tissue transformation is regulated by the strength of *Dhatvagni*, ensuring qualitative and quantitative nourishment.

Factors Affecting Agni

Several intrinsic and extrinsic factors influence the functioning of *Agni*:

- **Doshic balance:** Excess or deficiency of *Vata*, *Pitta*, and *Kapha*.
- **Dietary habits:** Quality, quantity, timing, and compatibility of food.
- **Seasonal variations:** *Ritucharya* suggests dietary adaptations per season to sustain *Agni*.
- **Mental state:** Psychological conditions like stress, anxiety, and depression can impair *Agni*.
- **Age and Physical activity:** Younger age and physical exertion enhance *Agni*, whereas ageing leads to its decline.

Physiological Functions of Agni

- **Digestion (*Ahara Pachana*):** Digests and assimilates food in the gastrointestinal tract.
- **Metabolism (*Dhatu Poshana*):** Governs tissue formation and energy metabolism.
- **Immunity (*Bala* and *Ojas*):** A robust *Agni* contributes to enhanced immunity and vitality.
- **Homeostasis:** Maintains internal balance through effective metabolic processing.
- **Disease Prevention:** Balanced *Agni* prevents accumulation of *Ama* (toxins), which is the root cause of diseases.

Clinical significance of Agni

In *Ayurveda*, assessing *Agni* is critical before initiating any treatment. A deranged *Agni* leads to *Ama* formation, resulting in metabolic disorders, gastrointestinal issues, and systemic diseases. Thus, strengthening and normalizing *Agni* through:

- **Deepana:** Appetizer herbs and therapies.
- **Pachana:** Digestive aids that eliminate *Ama*.
- **Shodhana:** Detoxification via *Panchakarma*.
- **Rasayana:** Rejuvenative therapies to enhance metabolic strength.

Importance of Agni

Thus, *Agni* is not just a digestive phenomenon but a comprehensive metabolic regulator that spans gastrointestinal, cellular, and systemic functions. It serves as the foundation for physiological strength, immunity, and mental clarity. Recognizing its role provides valuable insight into personalized healthcare, preventive medicine, and holistic treatment strategies as per *Ayurveda* [10].

Modern Review

Digestion begins in the mouth with mechanical mastication and enzymatic breakdown of carbohydrates by salivary amylase. The bolus then travels through the esophagus into the stomach, where hydrochloric acid and pepsin initiate the breakdown of proteins. Gastric secretions help maintain an acidic pH (1.5-3.5), which is essential for pepsin activation and pathogen control.

The chyme formed in the stomach is gradually released into the small intestine, where the majority of digestion and absorption occurs. The pancreas secretes digestive enzymes such as trypsin, chymotrypsin, amylase, and lipase, which respectively digest proteins, carbohydrates, and fats. Bile from the liver emulsifies fats, enhancing lipid digestion.

The small intestine is lined with villi and microvilli, significantly increasing the surface area for absorption of monosaccharides, amino acids, fatty acids, glycerol, vitamins, and minerals into the bloodstream and lymphatic system [11].

Metabolism: Cellular and Systemic Processes

Metabolism encompasses all biochemical processes that occur within living organisms to maintain life, primarily categorized into catabolism and anabolism:

- **Catabolism:** The breakdown of molecules to obtain energy. Example: Glycolysis breaks glucose into pyruvate, generating ATP.
- **Anabolism:** The synthesis of complex molecules from simpler ones, essential for tissue building and repair. Example: Protein synthesis from amino acids.

At the cellular level, mitochondria are the powerhouses where oxidative phosphorylation occurs, converting nutrients into ATP, the energy currency of the cell. Metabolic pathways include glycolysis, the citric acid cycle (Krebs cycle), beta-oxidation of fats, and the electron transport chain.

Key metabolic hormones regulating these processes include:

- **Insulin:** Facilitates glucose uptake and promotes glycogenesis and lipogenesis.
- **Glucagon:** Stimulates glycogenolysis and gluconeogenesis during fasting.
- **Thyroid hormones:** Increase basal metabolic rate and oxygen consumption.
- **Cortisol:** Involved in gluconeogenesis and lipolysis, especially during stress.

Thermogenesis and Energy Expenditure

Metabolism also contributes to thermogenesis—the production of heat in the body. Basal metabolic rate (BMR) defines the minimum energy expenditure necessary to maintain vital functions at rest. Factors affecting BMR include age, sex, body composition, and hormonal status.[12]

There are three components of total energy expenditure:

- **Basal Metabolic Rate (BMR):** Energy expended at rest.
- **Thermic Effect of Food (TEF):** Energy required for digestion, absorption, and nutrient processing.
- **Physical Activity:** Energy expended through movement and exercise.

Nutrient Assimilation and Tissue Formation

Once absorbed, nutrients undergo assimilation where they are converted into structural components of the body such as proteins, lipids, and nucleic acids. Amino acids contribute to muscle protein synthesis; fatty acids form phospholipids and triglycerides; glucose is stored as glycogen or converted into fat for energy reserves.[13]

Tissue-specific metabolic activities are finely tuned via localized enzymatic systems ensuring the unique needs of each tissue, such as:

- **Hepatic metabolism:** Detoxification, gluconeogenesis, and lipid metabolism.
- **Muscle metabolism:** Glycogen storage and utilization during physical activity.
- **Adipose metabolism:** Lipogenesis and lipolysis.

Homeostatic Regulation and Feedback Mechanisms

Metabolic processes are tightly regulated by feedback mechanisms to maintain internal balance. Examples include:

- **Glucose homeostasis:** Maintained via the insulin-glucagon axis.
- **Calcium balance:** Controlled by parathyroid hormone, calcitonin, and vitamin D.
- **Water and electrolyte balance:** Regulated by the renin-angiotensin-aldosterone system.

The hypothalamus plays a critical role in integrating hormonal signals to regulate hunger, satiety, and energy expenditure. Leptin and ghrelin hormones modulate appetite and energy homeostasis.

Clinical Relevance of Metabolic Functions

Disruptions in digestive and metabolic processes lead to a variety of diseases:

- **Metabolic Syndrome:** A cluster of conditions including insulin resistance, obesity, dyslipidemia, and hypertension.
- **Diabetes Mellitus:** Characterized by impaired glucose metabolism due to insulin deficiency or resistance.
- **Obesity:** Resulting from energy imbalance and disrupted fat metabolism.
- **Malabsorption Syndromes:** Conditions like celiac disease where nutrient absorption is impaired.
- **Gastrointestinal Disorders:** Such as irritable bowel syndrome (IBS), gastritis, and pancreatitis.

Modern Correlations of Agni Physiology

Ayurvedic Concept	Modern Correlation	Primary Functions in Modern Physiology
Jatharagni	Gastric digestion, Pancreatic enzymes, Bile secretion	Breakdown of proteins, carbohydrates, and fats in the GI tract
Bhutagni	Hepatic metabolism, Biotransformation in liver, Cellular metabolic pathways	Detoxification, nutrient conversion, molecular metabolism
Dhatvagni	Tissue-specific metabolism (e.g., hepatic, muscular, adipose)	Nutrient assimilation, tissue repair, energy storage
Samagni	Normal Basal Metabolic Rate (BMR), balanced enzymatic activity	Optimal digestion, absorption, and energy production
Tikshnagni	Hypermetabolism, Hyperthyroidism, Increased enzymatic action	Rapid digestion, weight loss, increased appetite
Mandagni	Hypometabolism, Hypothyroidism, Slow enzymatic activity	Sluggish digestion, weight gain, fatigue
Vishamagni	Erratic metabolism, Metabolic instability, IBS, Dyspepsia	Irregular digestion, fluctuating appetite, dysregulation
Ama	Toxin accumulation, Metabolic waste, Endotoxemia	Low-grade inflammation, metabolic disorders
Agni Vikriti (Deranged Agni)	Gastrointestinal disorders, Metabolic Syndrome, Diabetes	Impaired digestion, malabsorption, systemic diseases

Results and Findings

- *Agni* levels correspond to modern digestion, metabolism, and tissue-specific functions.
- *Samagni*, *Mandagni*, *Tikshnagni*, and *Vishamagni* reflect normal, hypo, hyper, and unstable metabolic states.
- Neuro-endocrine regulation (insulin, glucagon, thyroid hormones) governs metabolic balance.
- Impaired *Agni* parallels conditions like diabetes, obesity, metabolic syndrome, and hypothyroidism.
- Gut microbiota's role in digestion and immunity aligns with the importance of digestive health.
- Balanced metabolism is essential for homeostasis, energy production, and disease prevention.

Discussion

The concept of *Agni* in *Ayurveda* offers a comprehensive framework to understand the physiological processes of digestion, metabolism, and tissue nourishment, which are essential for maintaining health. Modern physiology elaborates these processes through the intricate functioning of the gastrointestinal system, metabolic pathways, enzymatic actions, and hormonal regulations. The digestion of food begins in the mouth and continues through the stomach, small intestine, and large intestine, involving multiple enzymes and secretions that ensure the effective breakdown and absorption of nutrients essential for survival and growth [14].

The role of metabolic hormones like insulin, glucagon, thyroid hormones, and cortisol is pivotal in regulating systemic metabolism and energy balance. Insulin facilitates glucose uptake, while glucagon maintains blood glucose during fasting. Thyroid hormones enhance basal metabolic rate, and cortisol plays a role in stress-induced metabolism. These hormonal controls ensure that the body maintains a dynamic balance between energy production, storage, and expenditure, analogous to the regulatory functions attributed to *Agni* [15].

Furthermore, the discovery of gut microbiota and its influence on digestion, immunity, and metabolism provides new insights into the importance of gastrointestinal health. Dysbiosis or imbalance in gut flora is now recognized as a contributing factor to metabolic disorders, obesity, diabetes, and even neurodegenerative diseases. This emphasizes the

need for maintaining optimal digestive function, which directly impacts systemic health, echoing the *Ayurvedic* emphasis on the centrality of *Agni* [16].

Clinically, disruptions in digestive and metabolic processes manifest in various chronic conditions such as metabolic syndrome, obesity, diabetes mellitus, hypothyroidism, and gastrointestinal disorders. These conditions reflect underlying disturbances in metabolic pathways, enzyme deficiencies, hormonal imbalances, or improper nutrient assimilation, all of which can be interpreted within the broader framework of impaired metabolic function described in modern medicine [17].

Thus, modern scientific understanding validates the significance of maintaining efficient digestion and metabolism for health preservation and disease prevention. This aligns with the classical emphasis on preserving the strength and balance of *Agni* to sustain vitality, immunity, and overall physiological harmony. The convergence of traditional insights and contemporary science can guide integrated approaches to metabolic health, emphasizing dietary management, lifestyle interventions, and metabolic monitoring [18].

Conclusion

The physiological understanding of digestion and metabolism in modern science highlights a highly coordinated system of enzymatic actions, hormonal regulation, and tissue-specific metabolic activities essential for maintaining health, energy balance, and homeostasis. Disruption in these processes leads to metabolic and systemic disorders such as diabetes, obesity, and gastrointestinal diseases. This reinforces the clinical importance of preserving digestive efficiency and metabolic integrity, which remains a central focus in health management and disease prevention in contemporary medical practice.

Conflict of interest: Nil

Source of support: None

References

1. Sharma RK, Dash B. *Charaka Samhita of Agnivesha*. Vol 1-3. Varanasi: Chaukhambha Sanskrit Series Office; 2017.
2. Tripathi B. *Charaka Samhita (Vidyotini Hindi Commentary)*. Varanasi: Chaukhambha Surbharati Prakashan; 2018.
3. Acharya JT. *Sushruta Samhita with Nibandha Sangraha Commentary*. Varanasi: Chaukhambha Sanskrit Sansthan; 2016.
4. Sharma PV. *Ashtanga Hridaya of Vagbhata*. Varanasi: Chaukhambha Orientalia; 2018.
5. Lad V. *Textbook of Ayurveda: Fundamental Principles*. Albuquerque: The Ayurvedic Press; 2002.
6. Shastri A, editor. *Ayurvedatatva Sandipika Commentary on Charaka Samhita*. Varanasi: Chaukhambha Sanskrit Series Office; 2015.
7. Gupta A, Mishra N, Tiwari S. Concept of Agni and its clinical significance in Ayurveda: A review. *Ayushdhara*. 2019;6(3):2145-2150.
8. Dwivedi A. Agni and its effect on health and disease: An overview. *J Ayurveda Integr Med Sci*. 2020;5(3):189-195.
9. Murthy KR. *Ashtanga Hridayam: Text, English Translation, Notes, Appendix*. Vol 1-3. Varanasi: Krishnadas Academy; 2002.
10. Pandey GS, Chunekar KC. *Bhavaprakash Nighantu*. Varanasi: Chaukhambha Bharati Academy; 2015.
11. Tortora GJ, Derrickson BH. *Principles of Anatomy and Physiology*. 15th ed. USA: Wiley; 2017.
12. Guyton AC, Hall JE. *Textbook of Medical Physiology*. 14th ed. Philadelphia: Elsevier Saunders; 2021.
13. Hall JE. *Guyton and Hall Textbook of Medical Physiology*. 13th ed. Philadelphia: Elsevier; 2015.
14. Ganong WF. *Review of Medical Physiology*. 26th ed. New York: McGraw-Hill Education; 2019.
15. Saladin KS. *Anatomy & Physiology: The Unity of Form and Function*. 9th ed. New York: McGraw-Hill Education; 2020.
16. Goyal M, Singh S, Gupta N, Kumar A. Role of gut microbiota in human health: An overview. *J Clin Diagn Res*. 2017;11(3):BE01-BE05.
17. Eckel RH, Grundy SM, Zimmet PZ. The metabolic syndrome. *Lancet*. 2005;365(9468):1415-1428.
18. Alberti KGMM, Zimmet P, Shaw J. Metabolic syndrome—a new world-wide definition. A Consensus Statement from the International Diabetes Federation. *Diabet Med*. 2006;23(5):469-480.