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Review

Telomerase Activators from the lens of Ayurveda: A review

[1*]Sonam Chawla

ABSTRACT:

Background: Increasing population of elderly across the globe has recognised the need for science-backed interventions and regimens to aid healthy ageing. *Ayurveda* has recognised *dhatu kshaya* (reduction or depletion of bodily tissues) as a key component contributing to *jara* (geriatric disposition) due to decline in composition and functioning of tissues and organs. *Ayurveda-backed* telomere activators are a promising strategy to identify molecules/*rasayanas* ("path to radiance" or the science of rejuvenation and longevity) that can preserve the telomeric ends and hence prevent activation of senescence, genome instability etc, correlating positively with higher rates of ageing. **Methodology**: A systematic search of "telomerase activator", "Ayurveda" with Boolean operator AND was performed in PubMed and Google Scholar, for the duration of 2015-2025. Free full text articles, in English language were retrieved and manually inspected for 1st report of telomerase activator action. **Results**: The present review narrates the state-of-the-art herba/rasyanas/bioactive compounds that have demonstrated telomerase activator action *in vitro*/*in vivo*/clinically. Namely - *Phyllanthus emblica* (*Amlaki rasayna*), *Withania somnifera* (*Ashwagandha), Centella asiatica (Mandukaparni), Astragalus membranaceus, Punica granatum,* and *Spirulina platensis* have been reviewed as telomere activators. *Centella asiatica (Mandukaparni)* emerged as the most investigated and utilized for commercial purpose, followed by *Astragalus membranaceus*. **Conclusion**: The review bridges the ancient science of *Ayurveda* with modern day telomere biology to put forth innovative anti-ageing solutions. *Ayurveda*-backed formulations/molecules that can activate telomerase can be potentially avert *dhatu kshaya* and improve the human health span.

KEYWORDS: *Ayurveda*, healthy ageing, telomere attrition, telomerase activators, *Dhatu kshaya*

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Corresponding Author Email:

contact.schawla@gmail.com

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1. INTRODUCTION:

WHO has recognized the year 2021-2030 as the "Decade of Healthy Ageing" and through this global initiative they intend to facilitate a healthy, active and a full life for the elderly population across the globe. [1] The number of people aged more than 60 years in age will increase from 1.1 billion to 1.4 billion by 2030, that is approximately 1 in 6 people will be more than 60 years old. [2] With increase in chronological age, comes physiological decline and age-related diseases such as - cardiovascular complications, metabolic syndrome and obesity, sarcopenia, neurodegeneration and Alzheimer's or Parkinson's disease etc. [3] Hence, management of ageing and age-related diseases will be a key agenda across global health agencies.

Understanding the molecular and cellular changes associated with ageing are elementary to management of ageing and its ensuing pathologies. In his landmark paper published in 2013, López-Otín and co-workers first described the hallmarks or identifiers of ageing at the cellular or organismal level. The paper described nine hallmarks, namely - telomere attrition or shortening, genomic instability, epigenetic alterations, loss of proteostasis, compromised nutrient sensing, mitochondrial dysfunction, onset of senescence, stem cell exhaustion and alterations in the intercellular communication and signaling *Ayurveda*, one of the oldest systems of traditional medicine dating back up to 500 BC, recognizes *jara* (ageing) as the "act of being worn out". [4, 5] The "*Swabhavoparamavada*" (natural destruction) theory described by the ancient sage Charaka states every living individual moves towards cessation or decay, following its own inherent nature, the "*Swabhava*" (intrinsic quality or disposition). [6] The modern scientists have in fact recognised the interrelated nature of the modern ageing hallmarks and the ancient *Ayurvedic* parallels, and have been described in Table 1. [7]

Table 1: The Modern-day Hallmarks of ageing and Ayurvedic parallels

Hallmark of Ageing	Proposed Ayurvedic Parallel	Elaboration
Genomic instability	*Beeja dushti* (defects in fundamental tissue/seed)	Deterioration at the fundamental cellular level as *Beeja* (seed) corruption.
Telomere attrition	*Dhatu kshaya* (tissue depletion)	The gradual shortening of telomeres parallels *Dhatu kshaya*, where tissue nourishment and integrity decline, especially with *vata* (wind, air or motion) aggravation in old age.
Epigenetic alterations	*Agni mandya* (weak digestive/metabolic fire)	Epigenetic changes are akin to impaired *Agni* (digestive fire) governing metabolism and production of energy from nutrients.
Loss of proteostasis	Imbalance in *Ojas* and *Srotas* (channels)	Proteostasis failure corresponds to the loss of *Ojas* (vital essence) and impaired *Srotas* (channels), which affects cellular function and immunity.
Deregulated nutrient sensing	*Prakriti* and *Satmya* (constitution and adaptability)	Ayurveda emphasis on *dincharya* (daily routine) and personalized diet and lifestyle changes, highlighting the key

		role of nutrient sensing pathways.
Mitochondrial dysfunction	*Agni* and *Prana* (digestive fire and life force)	Mitochondrial dysfunction is equated to weakened *Agni* and *Prana* energy, leading to fatigue and low energy production.
Cellular senescence	*Vata vriddhi* and *Dhatu kshaya*	Accumulation of senescent cells relates to aggravated *Vata* and tissue depletion, contributing to decreased cellular regeneration and increased ageing signs.
Stem cell exhaustion	Reduced *Ojas* and impaired *Dhatu* formation	Stem cell declines parallels diminished *Ojas* and impaired tissue regeneration capacity
Altered intercellular communication	*Manas* (mind) and *Prana* (life energy) imbalance	Disrupted cellular signaling can be viewed as disturbances in *Manas* and *Prana* .

The Geroscience Hypothesis proposes that decreasing the rate of aging process will delay the onset of pathological changes associated with aging. This decrease in the rate of aging can be an outcome of dietary changes, active lifestyle, uptake of bioactives/pharmacological entities etc. [8] One of the most science backed opportunities to promote healthy ageing is addressing the progressive shortening of telomeres. Telomeres are nucleoprotein ends of chromosomes, and have been observed to be replicated incompletely with each cell cycle leading to shortening generation after generation. Telomerase is the ribonucleoprotein complex responsible for synthesizing telomeric ends of chromosomes during cell cycle, and its activity is minimally present in somatic cells and additionally it declines progressively. [9] Although, in *Ayurveda*, a direct mention of "telomere shortening" is not conspicuous, the concept of "*Dhatu Kshaya*" or in modern day terminology - tissue depletion and predominance of *Vata* (one of the three *doshas* linked to imbalance in air and space) in elderly, resonates with the idea of progressive cellular ageing and functional decline. [10] The present narrative mini review, presents the state-of-the-art literature on the phenomena of telomere shortening, the mechanisms responsible for its onset, and the potential *Ayurvedic*/herbal interventions or regimes that can aid maintenance of telomeres, via telomerase activation in elderly populations to aid healthy ageing.

2. METHODOLOGY

Table 2: Search strategy outline

Database	Keywords used	Boolean Operator	Filters	Notes
PubMed (via MEDLINE), Google Scholar	telomerase activator, *Ayurveda, natural*	AND	English, free-full text research articles, 2015-2025	• Review articles were not considered • Manual curation of retrieved papers 100 papers was performed to include only those research articles that reported an *Ayurvedic* formulation/herbal extract/nutraceutical formulation/bioactive compound exhibiting telomerase activation potential for the 1st time.

A systematic search was performed in PubMed (via MEDLINE) and Google scholar using above keywords, Boolean operators, and filters described in table 2. A total of 11 free full text articles were included after manual curation for the first report of *Ayurvedic* formulation/herbal extract/nutraceutical formulation/bioactive compound exhibiting telomerase activation.

Telomeres: the caps of longevity

Muller coined the term telomere from Greek words *telos* (end) and *meros* (part) in 1938. As correctly described, the telomeres are essentially composed of repetitive DNA sequences, up to several kilobases in tandem repeats and at the 3' end there exists a single stranded 100-300 polynucleotide sequence overhanging (rich in GC content). This overhang folds back on itself to form the T-lariat (loop like) structure. The nucleic acid core at telomeres is complexed with six proteins forming the "Sheltrin complex". [11] Besides being a standalone hallmark of ageing, telomere shortening is closely interlinked with other age-related cellular disturbances, either as a cause or outcome. Namely, telomere shortening can trigger cellular senescence - the irreversible blockade of cell cycle and initiation of senescent associated secretory phenotype, contributing gravely to inflammaging. Exposure to extrinsic (UV radiation, chemicals) or intrinsic (redox imbalance) stressors activating the DNA damage response can lead to genome instability and epigenetic disturbances and are also linked to telomere attrition. [12]

The telomere shortening phenomena was described rightly under the "End Replication Theory"put forth by Olovnikov and James Watson in 1970s. [13, 14] They recognised that DNA polymerase requires an RNA primer to initiate replication. The lagging strand replicates via short segments caused the Okazaki fragments, and at the end of the lagging strand template, there's no space for the final primer to be placed. Hence, this leads to a small gap that goes unreplicated, cell cycle after cell cycle. Thus, the telomere shortens and can no longer protect the chromosome ends. [15] Direct evidence exist in support of telomere shortening correlating directly with decrease in replicative lifespan in isolated mammalian cells (faster attainment of Hayflick's limit *in vitro*), model organisms routinely used for ageing studies and in clinical investigations. [16] Hence strategies to preservation of telomere length are pivotal to exploring natural/synthetic interventions to aid healthy ageing.

Telomerase: structure and function

The telomerase is essentially composed of two subunits – the telomerase RNA and the catalytic subunit telomerase reverse transcriptase protein (TERT, abbreviated as hTERT for human TERT). The catalytic subunit is primarily responsible for synthesis of tandem repeats on the telomeric ends. As shown in Figure 1, the hTERT is composed of four domains. The N-terminal domain also called as TEN (telomerase essential N-terminal), the telomerase RNA binding domain (TRBD), the reverse transcriptase domain (RT), and the C-terminal domain (C-TD, also called as the "thumb" domain. [17] The TEN domain binds the single stranded DNA and the telomerase RNA and enhances the processivity (the ability to catalyze concurrent reactions without releasing the substrate) of the complex, the TBRD is responsible for recognition of the RNA

template. The RT domain has a "palm" and "finger" sub-domains, and three aspartic acids (negatively charged amino acids) in tandem at the active site. The RT domain is responsible for synthesizing the tandemly repetitive DNA at the telomeres on the RNA template, and maintaining the length of telomeres. Grossly, the somatic tissues are deficient/have low levels of telomerase activity and hence with progressive proliferation telomeres shorten as chronological age advances. Of adult cell types - stem cells, germ cells, and activated lymphocytes contain active and significant hTERT activity. [18] Hence the potential for telomerase activation by herbal supplementation/*ayurvedic* regimes is of high clinical value, considering the high patient compliance for safer and natural treatments/prophylactic interventions.

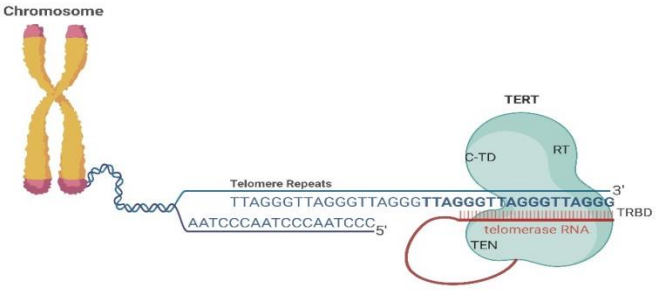

Figure 1: TERT structure and action. The relative positioning of the functional domains in 3D structure of TERT is depicted. The TEN domain located near the N terminal binds the ssDNA and the telomerase RNA template. Adjacent is the TRBD domain which recognizes the RNA template, and followed by the RT domain (catalytic domain) responsible for synthesis of telomeric DNA repeats of 5'TTAGGG3' on a template of telomeric RNA. The C-TD, also called the thumb domain is adjacent to RT domain and stabilizes RT-DNA interaction. The telomeric repeats are located at the end of the chromosomes (red ends of chromosomes).

Telomerase activators from *Ayurveda*

Ayurveda defines *Sapta Dhatus* (seven fundamental tissues of the body) as follows: : *rasa* (plasma/lymph fluid)*, rakta* (blood)*, mamsa* (muscles)*, meda* (fat)*, asthi* (bone)*, majja* (bone marrow)*, sukhra* (reporductive fluid) . [18] The authors hypothesize here that as telomeres shorten with chronological ageing, the cellular composition of the *sapt dhatus* declines in number and functionality (either via arrest of cell cycle and acquiring a senescence-associated secretory phenotype, or cell death). Reactivation of telomerase in the somatic tissues using herbal/*ayurvedic* treatment regimens can facilitate delaying the rate of cellular ageing and eventually enhance the healthspan of the subject

Key Findings from Literature Review: A staggering observation during the literature review was the limited availability of research on natural or *ayurvedic* telomerase activators, especially in light of the vast body of cumulative literature on telomere biology. This could be a consequence of the complex dynamics of telomere biology. Understanding modulation of telomere length and telomerase activity, as well as their quantification are intricate and pose experimental challenges. Additionally, raised telomerase enzymatic activity positively correlates with malignancy progression and aggressiveness, hence researchers need to cautiously design their studies, wherein detection of activation of cancer signaling pathways is a key component while evaluating pharmacological efficacy and safety of telomerase activators. Further, modern

medicine works principally on a reductionist approach of how a drug molecule interacts with a specific drug target, against the more holistic and individualized approach of *ayurveda*. This gap needs to be bridged by defining standardized protocols for evaluation of efficacy and safety of herbs and *rasayanas*, especially clinicals trials on telomerase activating ayurvedic formulations/natural molecules. A large proportion of studies are *in vitro* or *in vivo* (animal models). Hereafter we elaborate the *ayurvedic* formulations/herbs/natural molecules that have been documented in literature to be of "telomerase activators" (Figure 2).

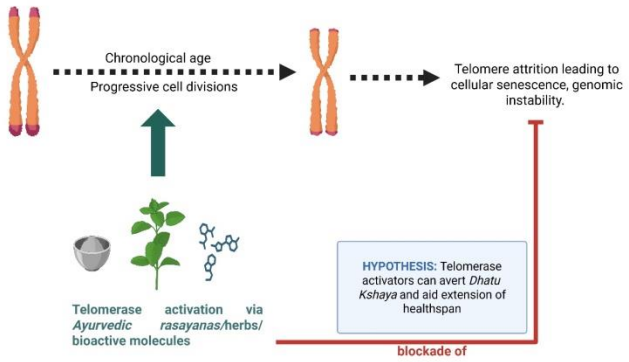

Figure 2: Mechanistic insight into role of telomerase activators from *Ayurvedic rasayanas*/herbs/bioactive molecules. As the age progresses, the telomeric ends are shortened with every cell cycle in the somatic tissues which are deficient in telomerase activity. *Ayurvedic rasayanas*/herbs/bioactive molecules that can activate telomerase enzyme activity (green arrow), and blockade of telomere attrition, and hence genome instability and cellular senescence. Hence the authors hypothesize that telomerase activators can avert *dhatu kshaya* and extend healthspan.

Amlaki rasayan

Amalaki Rasayana is prepared from the fruit of *Phyllanthus emblica*. The fruits of amla, as it is known in the Indian subcontinent are a rich source of vitamin C and a diverse array of bio-actives such as ellagic acid, quercetin, tannins, alkaloids, flavonoids etc. In the study by Guruprasad and co-workers healthy aged subjects (45–60 years of age), and young subjects (age control) were selected for the study, and underwent *koshta shuddhi* (stomach cleansing) for 1 week. The individuals were divided into *amalaki rasayana* administered or placebo group, 7th day onwards, for 45 days at a dose of forty-five grams per day. This treatment regimen exhibited increased telomerase activity in isolated peripheral blood mononuclear cells, in aged individual against the placebo group by 90th day. The same was reflected in aged individuals with normal as well as overweight basal metabolic rate, *amlaki rasyana* administration raised the telomerase activity temporally from the baseline. Additionally, the complete blood cell counts between experimental group and placebo group showed no significant deviation, endorsing the safety of the *rasayana*. This is in line with the role of *amalaki rasayana* being defined as a *vayasthapana rasayana (rasayana* for longevity and deflecting the geriatric disposition). [19]

Ashwagandha

Ashwagandha or *Withania somnifera* root extract is a well-recognized stress management herb in modern medicine as well as traditional systems across the globe. The root extract is rich in "withanolides", used as adaptogens and enhancing stress tolerance in young and elderly subjects. The study reported by Raguraman

and co-workers investigated the efficacy of *Ashwagandha* root extract (10µg/ml - 5mg/ml) treatment for a period of 72 h in enhancing the telomerase activity. The study reports a dose-dependent increase in telomerase activity up to 50 µg /ml, after which due to the extract suspension directly in media interfered with cellular viability. *Ashwagandha* by means of its telomerase activating potential is thus endorsed for aiding enhancement of health span in human subjects. [20]

Mandukaparni

Mandukparni or *Centenella asiatica* is prescribed for skin diseases, depression and anxiety, immunomodulation, venous efficiency, gastric ulcers etc in traditional medicine. *Mandukparni* extract formulation (08AGTLF) enriched in triterpenes (purchased commercially) was evaluated for activation of telomerase activity in comparison with herbal preparations from *Astragalus membranaceus* extract and individual bioactives oleanolic acid, maslinic acid and multi-nutrient preparations. The model system used was human peripheral blood mononuclear cells isolated from healthy subjects, treated with the interventional preparations in dose response curves (0.02, 0.2, 2 µg/ml). 24-72h post-treatment the *mandukparni* extract (08AGTLF) exhibited nearly 8-fold boost in telomerase activity, in comparison to untreated cells. [21] Additionally, Karsono and co-workers reported a novel extract named - DLBS1649 derived from *mandukparni,* that when evaluated in 3T3-L1 (adipose tissue) and HEK293 (human embryonic kidney cells) exhibited maintenance of telomere length in HEK293, with a congruent preservation of telomerase expression/activity and markers of cell cycle progress in the cell line. Further, in the differentiated 3T3-L1 cells simulating adipose tissue, the DLBS1649 extract mimicked calorie restriction and lower fat droplets as compared to resveratrol. The extract was then evaluated in lifespan extension studies in fruit flies (*Drosophila*) and significant increase in mean survival time was observed in male (>20%) and female flies (>10%). [22] The *mandukparni* extract was also reported as a component of a poly-herbal Thai formulation (Mylife/Mylife100®) administered subjects aged 50–65 years for 8 weeks. The leukocyte telomeric length was significantly raised from baseline in the treatment group in comparison to placebo group, along with raised plasma total antioxidant capacity levels. Although, the other components of the polyherbal formulation can also be underpinned for telomerase activation, but action of *mandukparni* cannot be negated. [23] Similarly, a nutraceutical formulation of *mandukparni* with vitamin C, zinc and vitamin D3 when administered in 18-month-old rats as compared to 3-month-old rats reigned the rate of telomere attrition, and even exhibited increased telomere length on being treated with higher doses. In addition, the telomerase activity was significantly raised in the peripheral blood mononuclear cells isolated from the treated rats vs untreated rats. [24]

Astragalus membranaceus

Astragalus membranaceus, is a prominent medicinal herb in traditional Chinese medicine, with significant anti-ageing property that slows down the rate of ageing. In 2011, Bernardes and co-workers reported a small molecule isolated from root of *A. membranaceus* to

lengthen the telomeric ends and depreciate the number of short telomeres as well as cognate DNA damage in mouse embryonic fibroblasts genetically engineered to contain only a single copy of the telomerase . [25] Other novel telomerase activator molecules reported from the root extract are derivatives of cycloastragenol, cyclocanthogenol, etc and astragaloside IV, evaluated in various cell lines, as well as disease models to confer anti-ageing and relieving pathological changes via telomerase activation . [26, 27]

***Punica granatum* L**

Punica granatum or pomegranate is a fruit recognized in *ayurveda* to be rich in vitamins, polyphenols, flavanoids, and tannins, its peels containing maximum antioxidant activity. A recent study wherein pomegranate peels were administered to aged rats for two months in comparison to positive control rats administered TA-65. Significantly raised telomerase activity, accompanied with raised markers of antioxidant defense (thioredoxin) was observed in rats treated with pomegranate peel extract. [28]

Spirulina platensis

Spirulina, an edible, filamentous bacterium is a globally recognized nutritional supplement. Sapogenins extracted from S*pirulina* were evaluated in MCF7 and HDF cell lines for impact on telomerase activity. The methanolic extract, although raised the telomerase activity but was highly toxic to MCF7 cells. Instead, the aqueous extract enriched in sapogenins raised the telomerase activity in HDF cells (normal, non-cancerous cells) and inhibited the telomerase activity in MCF7 cells (breast cancer cells). Hence, careful evaluation across cell types should be performed for ascertaining telomerase activator/inhibitor action. [29]

Table 3: Summary of some medicinal herbs/rasayana as a telomerase activators

Ayurvedic formulation/ herb/ bioactive molecule	**Type of study**	**Dosage and duration**	**Effects on telomerase activity/expression and allied markers**	**Ref.**
Amalaki Rasayana	Clinical	45 days at a dose of 45g/day	Increased telomerase activity and telomere length	[19]
Ashwagandha or *Withania somnifera* root extract	*in vitro* (He La cells)	50 µg /ml for 72h	Increase telomerase activity	[20]
Mandukparni or *Centenella asiatica* – extract 08AGTLF	*in vitro* (human peripheral blood mononuclear cells isolated)	0.02µg/ml for 24-72h	Increase telomerase activity	[21]
Mandukparni extract - DLBS1649	*in vitro* - 3T3-L1 HEK293 and *in vivo -Drosophila*	*in vitro* - 3T3-L1 (50, and 100 µg/mL for 14 days), HEK293 (25 and	Increased telomerase expression, telomere length (HEK293), decreased fat droplets (3T3-L1),	[22]

		50µg/ml till passage no. 43) *in vivo -Drosophila* (2mg/ml for 80 days)	increased mean survival time (*Drosophila*)	
Mandukparni extract as a part of poly-herbal Thai formulation (Mylife/Mylife100®)	Clinical (isolated leukocytes)	80 days (the formulation contained 150 mg *mandukparni* leaf powder)	Increased telomere length, plasma antioxidants	[23]
Mandukparni extract in nutraceutical formulation with vitamins and minerals	*in vivo* (18 months old rats)	2 capsules/kg bw/day for 3 months (each capsule had 9 mg *mandukparni* extract)	Increased telomerase activity, increased telomere length	[24]
Proprietary extract (TA-65) of dried root of *Astragalus membranaceus*	*in vitro* : Haploinsufficient ($Terc^{+/-}$) mouse embryonic fibroblasts, *in vivo*: 2-year-old C57BL ⁄ 6JolaHsd mice	*in vitro* : 10 µM every 24–48 h *in vivo:* 25 mg/kg body weight per day for 4 months.	Increased telomerase reverse transcriptase expression in cells and associated cell cycle markers (*in vitro*), increased healthspan (improved glucose tolerance, osteoporosis status and skin health, telomerase reverse transcriptase expression, decreased cancer incidence.	[25]
Astragaloside IV, Cycloastragenol from *Astragalus membranaceus*	*in vitro*: High glucose stress given to nucleus pulposus cells isolated from tail intervertebral discs of Sprague-Dawley rats	1, 3, 5 mM) for 24 h	Increased telomerase reverse transcriptase mRNA and protein expression, telomere length, lower senescence and apoptosis markers.	[26]
Biotransformed cyclocephagenol and its 12-hydroxy derivatives	*in vitro*	10, 30, and 100 nM	Increased expression of telomerase reverse transcriptase and telomerase activity	[27]

using *Camarosporium laburnicola*				
Punica granatum peels' extract	*in vivo* (10 months old Wistar rats)	250 mg/kg for 2 months	Increased expression of telomerase reverse transcriptase and other anti-oxidant defense markers, normalised liver histopathology	[28]
Aqueous extract of sapogenins from S*pirulina*	*in vitro* (MCF7 cells, HDF cells)	0.004 mg/ml of sapogenin extract for 24h	Decreased telomerase activity in MCF7 cells, and increased telomerase activity in HDF cells	[29]

3. DISCUSSION

Extension of human health span has been a common goal of modern and traditional medicine practices. Today, when the global elderly population is on the brink of crossing 1.4 billion, management of human health span by bridging traditional medicine practices such as *Ayurveda* and even traditional Chinese medicine in synchrony with state-of-the-art understanding of modern-day molecular medicine and pharmacology can offer innovative and efficacious solutions. [1, 2] Telomere attrition, leading to cellular senescence and genomic instability, is a recognised hallmark of ageing that can be closely interlinked to *dhatu kshaya*. [4, 5, 7, 8] Activation of telomerase reverse transcriptase enzyme or up-regulating its' expression can hence possibly offset *dhatu kshaya* and improve the health span. The present systematic review endorses our hypothesis, wherein evidence-based perspectives on A*yurvedic* formulations/*rasayanas*/herbs/bioactive molecules of natural origin that have demonstrated activation of telomerase activity and congruent preservation of health span. The most widely used herb for telomerase activation, also described in *Ayurveda*, is *mandukparni*. The leaf extracts have been used *per se* as well as in combination in nutraceutical formulations with other herbs and vitamins/minerals and have demonstrated positive correlation with telomerase activity and telomeric length preservation. In addition, health span and lifespan extension benefits were also observed across model organisms investigated – cell lines, *Drosophila*, and human subjects. [21-24] In terms of usage, *manudukparni* is followed by a herb from traditional Chinese medicine - *Astragalus membranaceus.* The herb's root extract is in fact available as commercially, by the trade name of TA-65, and has been demonstrated health span extension without increasing the incidence of cancer in animal studies. [25-27] Converse to the telomerase activation as an anti-ageing strategy, telomerase inhibition is an anti-cancer strategy. Thus, it is critical to evaluate cancer incidence in all interventional studies where telomerase activation is sought. Here the author also recommends that as *A. membranaceus* belongs to the Fabaceae family, *Ayurvedic* counterpart herbs in the same family

can be explored for potential telomerase activators.Interestingly, the same extract can demonstrate opposing action, as shown in sapogenins rich extract prepared from *Spirulina.* The extract increased telomerase activity in normal human dermal fibroblast cells, but inhibited the telomerase activity in cancerous MCF7 cells. Hence careful choice of cell line for assessment of telomerase activator vs inhibitor is critical. [29]

Other, *Ayurvedic* herbs/*rasayanas* that have demonstrated promising telomerase activation and health span extension efficacy are *amlaki rasayana*, *ashwagandha* and peel extract of *Punica gratum*. [19, 20, 28] Except *amlaki rasyana*, *ashwagandha,* and peel extract of *Punica gratum* have only been assessed for telomerase activation in pre-clinical models and warrant standardization of the extracts investigated and then only can they proceed to clinical evaluation.

CONCLUSION

The *Ayurvedic* herbs, formulations and bioactives as potential telomerase activators is an emerging avenue for promoting healthspan and lifespan. The present review narrates the growing evidence from recent studies on *Phyllanthus emblica* (*Amlaki rasayna*), *Withania somnifera* (*Ashwagandha), Centella asiatica (Mandukaparni), Astragalus membranaceus, Punica granatum,* and *Spirulina platensis* exhibiting measurable increase in activating telomerase, thereby supporting cellular viability and vitality. These findings bridge the ancient wisdom of *Ayurveda* with contemporary geroscience, highlighting the interplay between *dhatu kshaya* (tissue depletion) and telomere biology.

Authors Details:

[1*]Assistant Professor, Department of Biotechnology, Jaypee Institute of Information Technology, NOIDA (Main campus), Sector 62, Uttar Pradesh, INDIA-201309

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