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# AGING EFFECT ON SALIVARY GLAND : A REVIEW

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## ABSTRAK

Gangguan menelandan mulut kering merupakan kondisi mulut yang palingumumdialamioleh orang dewasa yang menua. Mulut kering meningkatkan risikokaries gigi, penyakit periodontal, kandidiasis, ulserasi oral, disfagia yang dapat berdampak negatif pada status gizi dan kualitas hidup. Air liur yang disekresikan dalam rongga mulut sangat pentinguntuk menelan makanan dan berperan penting dalam persepsi sensorik. Penuaan memengaruhi kelenjar ludah dan mengubah kuantitas dan kualitas air liur. Perubahan fungsi kelenjar ludah dapat berdampak buruk pada kesehatan mulut dan sistemik. Hipofungsi saliva dikaitkan dengan penurunan kemampuan mengunyah dan menelan serta persepsi rasa objektif. Banyak kondisi medis dan perawatan obat biasanya memengaruhi air liur melalui aktivitas antikolinergik pada orang dewasa yang lebih tua. Faktor gaya hidup juga akan mengubah air liur secara bertahap seiring berjalannya waktu. Selain atrofi kelenjar histologis, efek fisiologis penuaan menyebabkan perubahan fungsi kelenjar ludah karena penurunan intensitas rangsangan dan refleks pada populasi lanjutusia. Dengan bertambahnyausia, terjadi penurunan jumlahreseptor penciuman dan pengecap, penurunan rangsangan sarafterhadap air liur, dan penurunan perfusi darah di tingkat kelenjar. Hubungan yang kompleks antara penuaan dan perubahan saliva memiliki hasil yang bervariasi pada subjek lanjut usia dan masih memerlukan banyak penelitian untuk menunjukkan masalah utamanya.
**Kata Kunci:** *penuaan, mulut kering, kelenjar saliva, dewasa tua*

## ABSTRACT

Swallowing disorders and dry mouth are the most common oral conditions faced by aging adults. Dry mouth increases the risk of dental caries, periodontal disease, candidiasis, oral ulceration, dysphagia which can have a negative impact on nutritional status and quality of life. Saliva secreted in oral cavity is essential for food ingestion and plays an important role in sensory perception. Aging affects salivary glands and changes quantity and quality of saliva. Alterations in salivary gland function can have adverse effects on oral and systemic health. Salivary hypofunction is associated with decreased chewing and swallowing ability as well as objective taste perception. Many medical conditions and drug treatments usually affect saliva through anticholinergic activity in older adults. Lifestyle factors will also modify saliva gradually over time. Besides histological gland atrophy, physiological effects of aging cause changes in salivary gland function due to decreased intensity of stimulation and reflexes in elderly population. With increasing age, there is a reduction in the number of olfactory and taste receptors, decreased neuronal salivary stimulation and decreased blood perfusion at the gland level. Complex relationship between aging and salivary changes have variability results in elderly subjects and still need many research to point out the main problem.
**Keywords**: *aging, dry mouth, salivary gland, elderly adults*

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## INTRODUCTION

Population aging is occurring globally at an unprecedented rate, with the proportion of people aged 60 years and older expected to double by 2050. In addition to affecting physical and physiological abilities, aging also significantly impacts nutritional status. For example, decayed or missing teeth, poor oral hygiene, lack of saliva resulting in impaired oral processes, and taste and texture disorders can lead to reduced nutrient intake and result in malnutrition (Laguna et al., 2015; Laguna et al., 2016; Mingioni et al., 2016; Laguna et al., 2017). Swallowing disorders (dysphagia) and dry mouth (xerostomia, salivary gland hypofunction) are the most common oral conditions faced by aging adults.

Xerostomia is a subjective sensation associated with mucosal dehydration and decreased oral lubrication, which is not necessarily related to salivary gland hypofunction. People suffering from dry mouth conditions will not only experience problems with chewing and swallowing, but also problems with taste, speech and reduced tolerance of dentures. Furthermore, xerostomia increases the risk of dental caries, periodontal disease, candidiasis, oral ulceration, dysphagia, all of which can have a negative impact on nutritional status and quality of life. Renewed research interest in dry mouth has been driven by the increasing elderly population with chronic diseases and polypharmacy which in turn commonly cause dry mouth (Hu et al., 2002; Guggenheimer and Moore, 2003; Ship et al., 2002). Aging affects the ability to taste and smell due to reduced cognition, salivary hypofunction and reduced chewing ability due to loose dentures. All of these can lead to changes in appetite regulation leading to a lack of hunger, also known as the "anorexia of aging".

It is often believed that xerostomia in the elderly is related to age-dependent changes in the quantity and quality of salivary secretion (Sutarjo et al, 2024). Saliva is a complex biological fluid naturally secreted in the human oral cavity that is essential for ingestion of food and for the formation of a coherent, smooth and swallowable bolus. Saliva also plays an important role in sensory perception by diluting food components responsible for taste and aroma, allowing them to interact with the taste buds (Doyennette et al., 2011; Neyraud, 2014). In addition to its feeding-related functions, salivary secretion ensures continuous hydration of the mouth and exhibits antibacterial functions.

From a compositional perspective, saliva is a slightly acidic fluid mixture consisting mainly of water (99.5%), proteins (0.3%), including mucins and enzymes and inorganic substances (0.2%) (Humphrey and Williamson, 2001). Saliva also adheres to the oral surfaces and helps maintain the thickness of the salivary pellicle of 30-100 nm (Lendenmann et al., 2000; Morzel et al., 2014; Hannig et al., 2017) although its thickness can vary depending on the location of the pellicle in the mouth. Proteins, such as misionic glycosylated mucins, statherin provide saliva with unique rheological (viscosity, elasticity, stickiness), water-holding and lubricating properties (Laguna and Sarkar, 2017). Aging affects the salivary glands and changes the quantity (flow rate) and quality (e.g. ionic and protein composition, rheology, tribology) of saliva. Thus, older adults may suffer from dry mouth, taste disturbances, and poor oral hygiene, greatly affecting their quality of life. Heterogeneity may increase with age. Older people have diverse physiological and psychological characteristics. Consequently, some researchers have begun to emphasize the need to examine heterogeneity among individuals of the same age in addition to normative age patterns.

## RESEARCH METHODS

This study employs a comprehensive literature review methodology to synthesize current knowledge on the effects of aging on salivary glands. A systematic search strategy was implemented across major biomedical electronic databases, including PubMed/MEDLINE,

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Scopus, Web of Science, and Google Scholar, utilizing a combination of relevant keywords and MeSH terms (e.g., "aging", "elderly", "senescence", "salivary gland", "parotid gland", "submandibular gland", "saliva", "salivary flow", "xerostomia", "age-related changes"). The search was primarily limited to articles published in English within a defined timeframe (e.g., from 2000 to 2025) to focus on contemporary research. Inclusion criteria encompassed original research articles (observational, experimental, clinical studies involving human subjects or relevant animal models), systematic reviews, and meta-analyses that specifically investigated structural, functional, or compositional changes in salivary glands or saliva associated with the natural aging process.

## RESULTS AND DISCUSSION

### Physiological Changes In Salivary Glands Associated With Aging

Saliva plays an important role in maintaining oral health. Saliva functions include preservation, protection and repair of oral mucosal tissues, remineralization of teeth, and modulation of viral, fungal and bacterial populations (Figure 1). In addition, salivary fluid facilitates food breakdown, bolus formation and taste, and can buffer acids from the external and internal environment. Alterations in salivary gland function can have adverse effects on oral and systemic health. Individuals with reduced salivary output are prone to dental caries, oral mucositis, dysphagia, oral infections and altered taste.

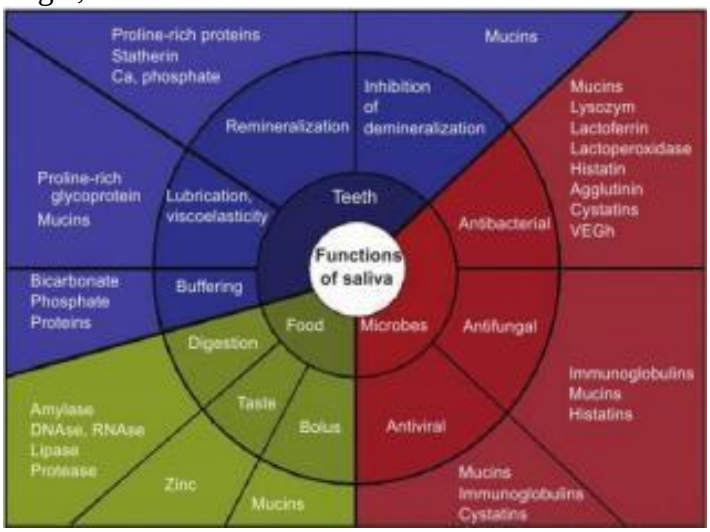


**Figure 1. Saliva Function**

Many older adults have salivary gland dysfunction and complaint of dry mouth (xerostomia). It was thought that salivary function decreases with age, but it is now accepted that the output of the major salivary glands is relatively unchanged in healthy individuals. Results of cross-sectional and longitudinal studies indicate that parotid salivary gland function in healthy individuals is generally age-independent. Furthermore, the constituents of parotid saliva do not change with age. Many medical conditions and treatments (including medications, head and neck radiation, and chemotherapy) can contribute to salivary gland dysfunction in older adults. There has been an attempt to explain the susceptibility of older adults to salivary dysfunction and xerostomia. Systemic problems and medications can affect the health of older adults as well as their oral conditions that can affect salivary physiology. However, older adults show great variability in oral and systemic health status, ranging from very healthy and without medications to permanently disabled and dependent.

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In humans, there are three main pairs of salivary glands that secrete 92-95% of the saliva secreted (parotid, submandibular and sublingual), while minor salivary glands are located in the buccal, labial, palatal and lingual regions, including the base of the tongue which secretes the rest. As shown in Figure 2, the parotid is the largest gland, located in front of the ear and behind the lower jaw secreted by Stensen's duct located in the buccal mucosa of the upper jaw first or second molar teeth. The parotid gland secretes serous; the submandibular gland is located in the posterior part of the floor of the mouth and is the smallest major gland. The submandibular gland secretes salivary fluid through the Warthon duct on the lingual frenulum with mucous and serous saliva types. The sublingual gland is located in the floor of the mouth with the Rivinus/Bartholin duct which secretes mucous salivary fluid. Salivary glands are composed mainly of three main types of cells (acinar, ductal and myoepithelial), which contribute to the secretion of saliva into a series of small ducts that open under the tongue.

Saliva is produced mainly in acinar cells, which also determine the type of secretion in different glands. Salivary glands in young individuals show a more even and compact lobar structure with a uniform shape of the parenchymal elements compared to older individuals. With age, histological studies of salivary glands have shown that although the number of ducts in the salivary glands remains the same, the proportional volume of fat and fibrovascular tissue increases in the parotid and submandibular glands of elderly individuals. On the other hand, the proportional volume of acinar cell secretion decreases in elderly individuals, which is considered to be one of the main causes of dry mouth (Vissink et al., 2010). All these histological changes can lead to overall salivary gland hypofunction.

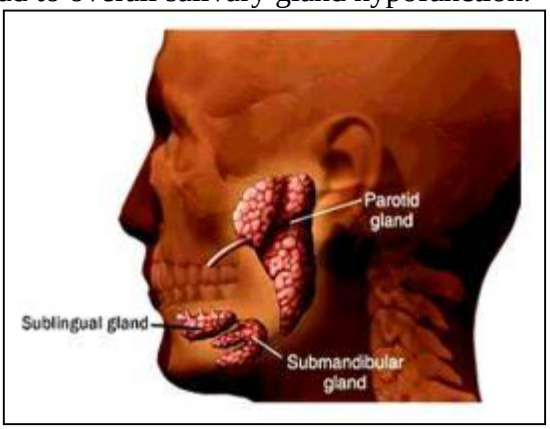


**Figure 2. Salivary Glands**

In the minor salivary glands, Sørensen et al. (2014) studied labial salivary gland tissue from the lower lip in 190 men (aged 61 years). Approximately 33% of the participants showed moderate to severe atrophy and fibrosis (31%). Although xerostomia did not correlate significantly with histological changes in the labial salivary glands, it was inversely related to the total nerve length in the connective tissue of the glands. In addition to histological gland atrophy, there are other investigated causes that may contribute to salivary gland hypofunction in the elderly population. The physiological effects of aging cause changes in salivary gland function due to decreased intensity of stimulation and reflexes. With increasing age, there is a reduction in the number of olfactory and taste receptors, decreased neuronal salivary stimulation (less transmitters acting on the receptors) and decreased blood perfusion at the gland level. In addition, increased diseases associated with aging and polypharmacy may also affect gland function.

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Salivary changes in aging can be grouped into quantitative (salivary flow rate) and qualitative (composition,rheology, lubrication) properties.

1. **Salivary Flow Rate**

Several studies have considered changes in salivary flow rate with age. No consensus has been reached on the decline in salivary flow rate with age. This is largely due to variations in study design or saliva collection methods. Affoo et al. (2015) conducted a meta-analysis including all published studies on saliva and age. Of the 47 studies finally selected, studies involving salivary flow rate were categorized into three groups, 1) submandibular and sublingual saliva; 2) parotid glands and 3) minor gland salivary flow rates. Affoo et al. (2015) reported that both stimulated and unstimulated mean salivary flow rates were significantly lower ($p < 0.001$) in older adults than in younger adults, with the difference being 66% higher in stimulated than in unstimulated saliva. The decline in salivary flow rate was specifically associated with saliva from the submandibular and sublingual salivary glands. However, parotid and minor gland salivary flow rates did not appear to be significantly lower. Interestingly, polypharmacy, i.e. the use of several medications, such as antidepressants, diuretics, analgesics, antihistamines, antihypertensives, antianxiety drugs and appetite suppressants, which is routinely prescribed in the elderly population cannot fully explain the differences in salivary flow rates between younger and older people. A recent study confirmed this by comparing healthy elderly (aged 70-92 years) and young subjects (aged 22-55 years). The researchers observed a mean reduction of 38.5% in resting salivary flow rate and 38.0% in stimulated salivary flow rate in elderly subjects compared to young subjects. The cause of the decrease in salivary flow has been justified in the study by the age-related evolution of the salivary glands, as described in the previous section: loss of acinar cells, loss of secretory tissue and increased adiposity as well as neurophysiological deterioration. Such a decrease in salivary flow rate has an indirect effect on salivary quality.

2. **Saliva Composition**

Most studies conducted with salivary changes were conducted with patients with burning mouth syndrome, Sjögren's Syndrome, or saliva analysis was performed after radiotherapy. There was a significant increase in the concentration of inorganic components in the elderly (n = 25, 70-86 years) compared to the young population (n = 26, 20-29 years). A recent study by Nassar et al. (2014) found a decrease in calcium ($Ca^{2+}$) when comparing two age groups of the population (old: n = 20, 60-80 years; young: n = 20, 30-60 years) in the case of unstimulated saliva, which is inconsistent with the data reported by Nagler and Hershkovich (2005). Although the mechanism for the decrease in salivary calcium is unclear, such a reduction in calcium has previously been observed in the serum of healthy elderly subjects. However, it should be noted that there was no standard age category in the study, which results in a potential source of variability in defining the elderly population/

For organic components, Nagler and Hershkovich (2005) found differences when reported as concentrations versus total amounts secreted (output). For example, although salivary protein concentrations increased with age, this was not significant. However, when expressed as secretion output, salivary proteins decreased significantly ($p < 0.05$). For amylase, the reverse was true, with concentrations significantly higher but output increases were not significant. This suggests that in some cases there is an age-dependent effect on secretion of a particular component, whereas the concentration effect is primarily driven by a decrease in salivary output. Salivary components are important in maintaining oral health. Salivary proteins, such as mucin, lactoferrin, lysozyme, peroxidase are required for non-immunological bacterial defense systems

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Several researchers observed reduced lactoferrin and peroxidase activity in healthy elderly subjects, thus modifying the balance between salivary antimicrobial agents contributing to oral tissue damage (Salvolini et al., 2000; Nagler, 2004; Dodds et al., 2005). These findings are in accordance with age-related histological and physiological changes in the salivary glands. Not only the quantity, but also the nature of mucin can influence the perception of oral dryness associated with changes in the composition of salivary residues and ions (Chaudhury et al., 2015). Dry mouth patients showed altered rheological properties of saliva and reduced mucosal hydration, indicating functionally compromised saliva, mostly associated with decreased MUC5B and MUC7. The reduced amount of mucin resulted in a thinner adsorbed layer on the anterior hard palate, i.e. the thickness in normosalivation ranged from 7.6 to 57.2 µm, while in hyposalivation cases it ranged from 3.4 to 25.7 µm. This is known as "enamel pellicle", which induces a weakening of the oral mucosal protection and enamel demineralization (Lee et al., 2002; Lindh et al., 2014; Proctor, 2016). With reference to enamel demineralization, salivary calcium is required in the reformation of the enamel pellicle with salivary proteins. Evidence of decreased calcium levels in healthy elderly people together with reduced salivary protein secretion can significantly affect oral health in the elderly population (Lendenmann et al., 2000; Nagler and Hershkovich, 2005). Therefore, mucin deficiency not only causes oral diseases due to lack of defense but also dryness of the oral mucosa.

**The Effect Of Saliva Changes On Food Taste Perception In The Elderly**

All non-volatile food components need to be dissolved in saliva to reach taste receptors. In addition, the role of saliva is also implicit in the oral sensation caused by food components, such as astringency caused by the complex of food polyphenols and salivary proteins (Brossard et al., 2016; Laguna and Sarkar, 2017). On the other hand, the effect of changes in inorganic ion concentrations can increase the taste threshold and decrease the supra- threshold intensity which provides an explanation for the elderly suffering from taste disorders. It has also been shown that this age-related decline in taste sensitivity is not only related to a decrease in the number of taste buds (Shin et al., 2012), but also to the production of salivary cells that produce a time lag in the turnover of taste receptor cells. It is known that the response to sucrose and sweet perception is pH dependent. Therefore, changes in the inorganic composition of saliva resulting in changes in salivary pH can explain its effect on receptor stimulation indirectly affecting sweet perception in the elderly population.

**Discussion**

Although not yet associated with aging, changes in salivary flow have shown a significant positive correlation between salivary flow and time to reach maximum intensity of sweet and cherry taste in chewing gum. Therefore, age-dependent changes in salivary composition may have a direct influence on taste perception and may consequently affect food intake (Boesveldt et al., 2018). In a systematic review (Muñoz-González et al., 2018), it was concluded that salivary hypofunction is associated with decreased chewing and swallowing ability as well as objective taste perception. Interestingly, little attention has been paid in the literature to investigate the relationship between salivary flow and texture or aroma on the one hand and salivary composition, taste/texture perception and food intake on the other. This suggests that further research is needed in this area to understand the role of hyposalivation on potential decreased aroma/texture perception and its consequences on food intake.

It is clear that age-related changes in saliva are multifactorial. On the one hand, reduced salivary flow rate has an effect on increasing the ionic concentration of saliva, inadequate fluid

levels to coat the oral cavity and reduced ability to overcome the pellicle. On the other hand, decreased salivary mucus and calcium may cause loss of salivary lubricating properties, which may result in reduced oral surface moisture and ultimately lead to xerostomia. There is still a need for research to study the age-related changes in saliva properties, especially regarding its role as a lubricant. For example, changes (if any) in the friction coefficient, viscosity and viscoelasticity of saliva in healthy elderly population due to decreased mucin and other organic components, calcium, increased other ions in elderly subjects remain to be elucidated.

## CONCLUSION

Aging significantly affects the salivary glands, resulting in changes in both the quantity and quality of saliva secretion, which contribute to common oral problems such as dry mouth (xerostomia) and difficulty swallowing (dysphagia) in the elderly population. This dry mouth condition increases various oral health risks, including caries, periodontal disease, candidiasis, and ulceration, and can negatively impact nutritional status and overall quality of life. The decline in salivary function in the elderly is not only caused by age-related physiological changes such as gland atrophy, decreased intensity of sensory stimuli (olfactory, gustatory), attenuation of the salivary reflex, and decreased blood perfusion to the glands, but is also often exacerbated by comorbid medical conditions and side effects of medications, especially those with anticholinergic activity. The interaction between the intrinsic aging process and extrinsic factors is complex with variable clinical manifestations, so further research is still needed to elaborate the main mechanisms of age-related salivary changes and develop effective interventions.

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