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Nutrition and Oral Health: The Role of Cariogenic Foods

Merve AYVAT-ÜNAL[1] Merve İNCE-PALAMUTOĞLU[2*] Murat İNCE[3]

[1] BSc, Department of Nutrition and Dietetics, Institute of Graduate Education, Afyonkarahisar Health Sciences University, Afyonkarahisar, Türkiye, merve_ayvat@hotmail.com

[2] Asst. Prof. Department of Nutrition and Dietetics, Faculty of Health Sciences, Afyonkarahisar Health Sciences University, Afyonkarahisar, Türkiye, merve.palamutoglu@afsu.edu.tr

[3] Dr. Dentince Dental Clinic, İstanbul, Türkiye, dentince@gmail.com

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ABSTRACT

Oral and dental health is a fundamental health indicator that directly impacts not only an individual's biological well-being but also their quality of life, social interactions, and psychological well-being. The World Health Organization defines oral health not only as the absence of disease, but also as the maintenance of functions critical to daily life, such as chewing, speaking, and laughing. This study examines in detail the effects of cariogenic nutrients on common oral diseases such as tooth decay, periodontal disease, and dental erosion. Findings indicate that sugary and acidic beverages cause demineralization of tooth enamel, while starchy foods promote bacterial growth in the oral microflora, facilitating plaque formation. Furthermore, it has been determined that inadequate protein and micronutrient intake weakens the defense capacity of periodontal tissues, paving the way for disease progression. Therefore, adequate and balanced dietary habits, in addition to regular brushing and hygiene practices, play a crucial role in maintaining oral and dental health. This study suggests that healthcare professionals should develop approaches that inform about cariogenic foods and encourage preventive dietary strategies.

Beslenme ve Ağız Sağlığı İlişkisi: Karyojenik Gıdaların Rolü

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ÖZET

Ağız ve diş sağlığı, bireyin yalnızca biyolojik açıdan değil, yaşam kalitesi, sosyal etkileşimleri ve psikolojik iyilik hali üzerinde de doğrudan etkili olan temel bir sağlık göstergesidir. Dünya Sağlık Örgütü, ağız sağlığını yalnızca hastalıkların yokluğu şeklinde değil; aynı zamanda çiğneme, konuşma ve gülme gibi günlük yaşam için kritik olan işlevlerin sürdürülebilmesi olarak tanımlamaktadır. Bu çalışmada, karyojenik besinlerin diş çürüğü, periodontal hastalıklar ve dental erozyon gibi yaygın ağız hastalıkları üzerindeki etkileri ayrıntılı olarak ele alınmıştır. Bulgular, şekerli ve asitli içeceklerin diş minesinde demineralizasyona neden olduğunu, nişastalı gıdaların ağız mikroflorası üzerinde bakteri üremesini teşvik ederek plak oluşumunu kolaylaştırdığını göstermektedir. Ayrıca protein ve mikro besin öğelerinden yetersiz beslenmenin periodontal dokuların savunma kapasitesini zayıflatarak hastalıkların ilerlemesine zemin hazırladığı saptanmıştır. Bu nedenle, düzenli fırçalama ve hijyen uygulamalarının yanı sıra yeterli ve dengeli beslenme alışkanlıkları, ağız ve diş sağlığının korunmasında önemli bir rol oynamaktadır. Bu çalışma, sağlık profesyonellerinin karyojenik besinler konusunda bilgilendirici ve koruyucu beslenme stratejilerini teşvik edici yaklaşımlar geliştirmesi gerektiğine işaret etmektedir.

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***Corresponding Author:** Merve İNCE-PALAMUTOĞLU, merve.palamutoglu@afsu.edu.tr

INTRODUCTION

Oral health is not limited to the teeth alone; it also includes the gums, the hard and soft palate, the oral and oropharyngeal mucosa, the lips, the salivary glands, the masticatory muscles, and the upper and lower jaws.[1] According to the World Health Organization (WHO), oral health is the absence of diseases and conditions affecting the oral and teeth, allowing individuals to eat, speak, and smile comfortably, while being free from pain, infections, and oral cancers.[2] Maintaining good oral health therefore does not only mean the absence of tooth decay and gum disease; it also refers to being free from chronic oral conditions, cancers of the oral cavity and throat, soft tissue lesions, congenital malformations such as cleft palate and lip, and other diseases or abnormalities that affect the mouth, teeth, and craniofacial tissues.[1]

Oral and dental health are important throughout life, as they ensure vital functions including speaking, chewing, tasting, and communication. Even though the public often does not perceive oral diseases as a major global health problem, the World Health Organization emphasized their significance in the Global Oral Health Status Report: Towards Universal Health Coverage for Oral Health by 2030.[3] The most common oral health conditions are untreated caries of primary and permanent teeth, severe periodontal disease, total tooth loss (edentulism), and cancers of the lips and oral cavity.[4]

METHODS

For this review, studies published between 2010 and 2024 were searched in PubMed, Scopus, Web of Science, and Google Scholar. The keywords ‘nutrition and oral health,’ ‘cariogenic foods,’ ‘dental caries,’ ‘periodontal disease,’ and ‘dental erosion’ were used. In line with the subheadings of the review, publications examining the effects of oral and dental health on general health, food groups supporting oral health, the effects of cariogenic foods, and the relationship between cariogenic food consumption and dental caries, periodontal disease, and dental erosion were included. Inclusion criteria were full-text human studies published in English or Turkish and directly related to the topic. Animal studies, conference abstracts, and papers indirectly addressing the subject were excluded.

The Effects of Oral and Dental Health on General Health

Scientific research and clinical data have demonstrated a correlation between oral health and general health.[5,6] Studies, particularly in recent years, suggest that this relationship is bidirectional. This bidirectional relationship is explained by the fact that symptoms of some systemic diseases can be observed in the mouth, and oral health can have a direct or indirect impact on general health.[7,8]

Numerous scientific studies have demonstrated that oral diseases can impact not only the oral cavity but also the overall health of the body. Shetty et al. [9] examined the relationship between periodontal disease and cardiovascular disease and revealed that gingivitis can increase the risk of heart disease. Periodontal disease is believed to be linked to bacterial infections in the mouth, which can spread to the bloodstream and trigger inflammatory processes in other parts of the body. This can have serious consequences that threaten cardiovascular health. Preshaw et al. [10] examined the effects of dental health on diabetes and found that periodontal disease is more common in individuals with diabetes. Evidence suggests that periodontal disease may hinder the regulation of blood sugar levels. The fact that diabetes creates an inflammatory environment in the body and negatively impacts oral health indicates a two-way relationship. Gum disease can further exacerbate this cycle, making diabetes control difficult. Kiecolt-Glaser et al. [11] found that tooth loss and oral health disorders are associated with psychological disorders such as depression and anxiety. It is believed that factors such as aesthetic concerns and pain can negatively impact the mental state of individuals with poor

dental health. Oral health problems can lead to loss of self-confidence and social isolation, which can have long-term adverse effects on mental health. These studies demonstrate that oral and dental health play a decisive role in systemic health. In this context, oral health should be considered not only within the framework of periodontal problems but also within a holistic health approach.

Food Groups for Oral and Dental Health

After describing the systemic relevance of oral health, it is important to identify which food groups support oral tissues and help maintain a healthy oral environment. Foods are classified into three groups: cariogenic, cariostatic, and anticariogenic, based on their impact on oral health. The cariogenic effect of a food varies depending on several factors, including its type, form (liquid, solid or slow dissolving), nutritional content, whether it is consumed with other foods and beverages, the duration it remains in the mouth, and the frequency of consumption. Cariogenic foods contain fermentable carbohydrates and cause the formation of organic acids by microorganisms in the mouth, lowering salivary pH below 5.5, which accelerates tooth decay. Foods that do not cause tooth decay, are not metabolized by microorganisms, and do not lower salivary pH below 5.5 are considered cariostatic. Protein-rich foods (eggs, fish, meat, chicken, seafood), oils, high-fiber and polyphenol-containing foods (especially raw vegetables and apples), and oilseeds (especially peanuts) exhibit cariostatic properties due to their low carbohydrate and high fat content. Anticariogenic foods, when consumed before acidogenic foods, prevent plaque from forming in response to acidogenic foods. Cheese is considered an anticariogenic food due to its high content of casein, calcium, and phosphorus. Furthermore, various studies have demonstrated that cheese helps prevent tooth decay and promotes remineralization by increasing oral pH.[12]

Effects of Cariogenic Foods on Oral Health

In contrast to foods that support oral health, cariogenic foods promote acid production and represent the primary dietary risk factor for oral diseases. Cariogenic foods are foods that trigger tooth decay and harm oral health. The primary cause of tooth decay is the fermentation of carbohydrates by bacteria in the mouth, which produces acids. These acids dissolve tooth enamel, leading to tooth decay and cavities. Carvalho and Lussi [13] found that foods high in sugar create an acidic environment in the mouth, which leads to the demineralization of tooth enamel. Constant consumption of acidic beverages weakens tooth enamel and increases the risk of cavities. In addition to sugar, acidic drinks can negatively affect the bacterial flora in the mouth by lowering pH levels. Moynihan and Kelly [14] found that high-carbohydrate foods facilitate the rapid proliferation of bacteria in the mouth, which in turn increases cariogenic effects. Carbohydrates form a sticky layer on the tooth surface, which promotes plaque formation and facilitates bacterial growth. This can accelerate the development of tooth decay. A key factor that increases the impact of cariogenic foods on oral health is the presence of fermentable carbohydrates. In particular, the presence of sugar and starch in the same product accelerates the caries formation process by increasing acid production by oral microorganisms.[15] The literature highlights the high cariogenic potential of white bread, desserts, and fast-food products. Lussi et al [16] demonstrated that fruit juices, due to their acidic nature, can cause permanent damage to tooth enamel, and that sugary drinks accelerate this damage. The study suggests that acidic beverages can cause imbalances not only in tooth enamel but also in the bacterial flora of the mouth, leading to an increased risk of caries. Rocha et al. [17] reported in their cross-sectional study of preschool children that those in the highest tertile of cariogenic ultra-processed food consumption had a 11.6% higher prevalence of dental caries

and an 8% higher prevalence of dental pain compared with those in the lowest tertile. These studies highlight the adverse effects of cariogenic foods on dental health and suggest that such foods should be consumed in limited quantities to maintain oral hygiene.

The Relationship Between Cariogenic Food Consumption and Tooth Decay

Among oral diseases influenced by cariogenic foods, dental caries remains the most prevalent. Dental caries is a multifactorial, contagious, and infectious oral disease that develops over time because of the interaction between cariogenic oral microorganisms and dietary fermentable carbohydrates. In the literature, dental caries is defined as a multifactorial infectious disease caused by the interaction of acid-producing bacteria, fermentable carbohydrates, and the quantitative and qualitative properties of saliva.[18] Carious lesions are characterized by demineralization of the hard tissues of the tooth, structural deterioration in these tissues, and inflammatory responses in the pulp tissue. Four fundamental factors contribute to the development of the disease: the structural characteristics of the tooth, cariogenic microorganisms, fermentable carbohydrates, and the duration of these factors act on the tooth.[19]

A dynamic balance exists between pathological and protective factors in the development of tooth decay. Organic acids released as a result of the anaerobic metabolism of dietary fermentable carbohydrates, considered a pathological factor, have been shown to cause demineralization in the hard tissues of the tooth and constitute a local risk factor for caries development. The frequency of carbohydrate consumption, the chemical structure of the consumed carbohydrates, and an individual's oral hygiene habits are essential determinants of caries development. Consuming highly sticky foods (e.g., candies, caramel products, dried fruits) and subsequent inadequate oral hygiene can accelerate the caries development process.[19,20]

Carbohydrates that begin to be broken down in the mouth by the enzyme amylase in saliva are defined as "fermentable carbohydrates." Both human and animal studies have reported that these carbohydrates, especially sugars, are among the primary dietary components that promote the development of dental caries.[19] The primary sources of carbohydrates in the diet are starch and sugars. While starch is not as directly cariogenic as sugar, it can contribute to caries formation under certain conditions. For example, there is no strong epidemiological evidence to suggest that natural starch sources, such as rice and potatoes, are a significant cause of tooth decay. However, starches that have been ground, heat-treated, and gelatinized during this process are more easily broken down and fermented by the enzyme amylase in saliva, leading to a decrease in oral pH and increasing the risk of caries. Foods containing processed starches, such as white bread and fried potatoes, have been reported to have the potential to cause caries. Furthermore, as food remains longer in the mouth, the capacity of starches to enzymatically convert to sugars and lower plaque pH increases, increasing the risk of tooth decay.[21]

Current studies indicate that frequency, rather than quantity, is a determining factor in caries development. Frequent consumption of sugary and starchy foods throughout the day leads to prolonged low oral pH and chronic demineralization of the enamel surface. Furthermore, foods containing sugar and processed starch (biscuits, crackers, cakes, etc.) have been reported to have a higher caries-causing potential than sugar alone. School-aged children are a particularly high-risk group due to their frequent snacking behaviors and easy access to packaged foods. These findings support the critical importance of reducing the frequency of cariogenic foods in reducing caries risk.[15]

Carbohydrate sugars are mainly classified as monosaccharides (glucose, galactose, and fructose) and disaccharides

(lactose, maltose, and sucrose). In foods, sugars are divided into two groups: intrinsic sugars, naturally present in dairy products, vegetables, fruits, and free sugars, which are added during processing to enhance sensory properties or increase energy content. Among them, sucrose is recognized as the most cariogenic sugar, while lactose exhibits lower acidogenicity and thus a more limited cariogenic potential. Studies report a significantly lower prevalence of dental caries in individuals with minimal or no sucrose intake. Reducing sucrose consumption is one of the most effective strategies for preventing caries, although its widespread use persists due to high energy value, low cost, availability, and stability during heat processing. Sucrose not only serves as a substrate for acid production by oral microorganisms but also plays a critical role in dental plaque formation, as bacteria such as Streptococcus mutans metabolize it to produce extracellular glucans that promote microbial adherence and caries development.[21]

The Relationship Between Cariogenic Food Consumption and Periodontal Disease

Beyond caries, cariogenic dietary patterns are also linked to periodontal disease. Periodontal disease (gum disease) is a chronic condition affecting the supporting tissues of teeth. If left untreated, it can impair chewing function, leading to tooth loss, which can negatively impact food intake and, consequently, an individual's nutritional status.[22] Gum health is influenced by various factors, including oral hygiene, genetic and epigenetic factors, systemic health, and dietary habits. Current findings suggest that nutritional supplements and specific nutritional components may play a role in the healing process after periodontal surgery.[23] Furthermore, serious periodontal diseases, such as gingival bleeding and periodontitis, can be associated with unbalanced dietary habits, including excessive carbohydrate consumption, inadequate protein intake, and deficiencies in vitamins A, C, E, B_{12}, and calcium.[24]

Vitamin A is essential for epithelial protection, and its deficiency may result in gingival alterations and alveolar resorption. Deficiencies in B vitamins, particularly folic acid, are linked to reduced resistance to bacterial attack and impaired periodontal tissue health. Vitamin C contributes to periodontal health through its antioxidant activity and its role in connective tissue maintenance; deficiency can cause scurvy and is strongly associated with periodontitis, while supplementation supports tissue repair. Overall, antioxidant vitamins such as A, C, and E are critical for maintaining periodontal integrity, and they are abundantly available in fruits, vegetables, and grains.[22]

The Relationship Between Cariogenic Food Consumption and Dental Erosion

Another condition strongly associated with acidic or fermentable foods is dental erosion. Dental erosion is a destructive process characterized by the irreversible loss of material from the hard tissues of teeth due to chemical factors, independent of bacterial influences. Prolonged and frequent exposure of enamel to acidic solutions with a pH below approximately 5.5 has been reported to lead to erosion.[25] Internal and external acid sources that create an acidic pH in the oral environment play a significant role in the development of dental erosion. Dietary sources of acidic beverages, foods, and some medications are among the extrinsic acid sources. At the same time, conditions such as gastroesophageal reflux and vomiting contribute to the erosion process by allowing intrinsic acids to reach the oral cavity.[26]

Intrinsic acids originate from the body and can cause erosion on tooth surfaces due to the reflux of stomach contents into the esophagus and oral cavity. Extrinsic acids include extrinsic factors such as acidic beverages, foods, some pharmacological agents, and environmental exposures. Numerous studies have shown that chewing vitamin C preparations or supplements containing hydrochloric acid can lead to significant dental erosion. Dietary acids are the most common extrinsic acids. Numerous

studies have reported that carbonated beverages, including sports drinks and colas, can lead to dental erosion. Interestingly, beverages marketed as low-calorie or sugar-free, though intended to reduce caries risk, often exhibit a high erosive potential. The extent of this effect is largely determined by the beverage's pH and buffering capacity. Natural products may pose a risk for dental erosion due to their high acidity, and sports drinks are reported to have a greater erosive effect than fruit juices. The addition of minerals such as calcium to beverages, however, can help reduce the demineralization of enamel tissue. For instance, although yogurt has a low pH value (≈4), its high calcium and phosphate content may prevent it from exerting an erosive effect.[25]

The Effects of Nutrition on Oral and Dental Health

Nutrition can have both positive and negative effects on the integrity and function of oral tissues. Conversely, deterioration in oral health can negatively impact basic functions, such as chewing and swallowing, thereby impairing food intake and, consequently, overall nutritional status. This can, over time, increase the risk of developing various chronic systemic diseases. Indeed, the WHO defines the role of nutrition in maintaining and improving oral health as a fundamental public health element, emphasizing the importance of nutrition-based preventive strategies.[27]

Oral health is reported to be influenced by various factors, including macro and micronutrients, vitamin intake, dietary pH, and eating habits. Furthermore, an individual's life stage, current health status, and socioeconomic circumstances also influence their nutritional needs and dietary preferences. Periodontal health is directly affected by nutrient intake. It has been reported that consuming unprocessed complex carbohydrates, plant-derived proteins, omega-3 fatty acids, and a balanced intake of vitamins and minerals can reduce periodontal inflammation, whereas consuming refined carbohydrates, animal-derived proteins, pro-inflammatory saturated fatty acids, and an inadequate or unbalanced intake of vitamins and minerals can increase the inflammatory response in periodontal tissues.[28]

Du et al. [29] reported that glucose, fructose, maltose, and sucrose exhibit only minor differences in their acid-forming capacity. However, when evaluated in terms of cariogenic potential, sucrose is considered the highest risk factor, followed by glucose, maltose, and fructose. The high cariogenic potential of sucrose stems from its ability to be easily fermented by oral microorganisms and its role as a substrate for the synthesis of extracellular and intracellular polysaccharides in dental plaque. The cariogenic effects of sucrose and other sugars are directly related to the frequency and amount of exposure. A study by Souza et al. [30] reported that consuming starch and sucrose together has a higher caries-causing potential than sugars alone. Although the World Health Organization recommends that free sugars intake be below 10% of total energy intake, current literature indicates that this limit is significantly exceeded, particularly in children and adolescents. Higher than recommended free sugars intake is one of the primary nutritional problems contributing to the increased prevalence of caries in the general population.[15] Milk contains approximately 4–5% lactose, which oral microorganisms can ferment; however, the fermentation rate is significantly lower compared to sucrose. The study reported that sucrose lowers the pH to below 5.0, while lactose lowers it to levels of approximately 6.0. A pH below 5.5 is considered a critical threshold for demineralization of tooth enamel. In this context, lactose, found in milk and dairy products, has been determined to have lower acid production and less cariogenic potential compared to other common sugars.[31] Inadequate protein intake increases susceptibility to infection in the soft tissues of the oral cavity, delays wound healing, and negatively affects the natural antibacterial properties of saliva.[32] Cow's milk proteins are reported to have particularly positive effects on

dental health. The anticariogenic effect of caseins, which constitute approximately 80% of milk proteins, is attributed to their ability to adsorb to the enamel surface, thereby buffering the acidic environment by increasing plaque pH, and the presence of casein phosphopeptides. Casein phosphopeptides increases the mineral level in dental plaque by stabilizing calcium phosphate in solution, thereby supporting remineralization on the enamel surface.[33] Protein-rich foods, such as milk, yogurt, and cheese, are generally considered to have low cariogenic potential because the urea released during digestion neutralizes the acidic pH and suppresses tooth demineralization. In addition, their high calcium and phosphate content, strong buffering capacity, and the presence of lactose, casein, and casein phosphopeptides reinforce the dental health-supporting properties of these foods.[34] The study by Tutus and Karımkhanı [35] conducted among adults reported that oral health indicators significantly worsened with increased consumption of sugary foods and beverages, whereas oral health scores improved with higher intake of dairy products and protein. These findings support the anticariogenic and protective role of dairy products and high-protein foods, as well as the detrimental effects of cariogenic foods. The type of fat in the diet has been reported to have a significant impact on both overall health and periodontal health. High consumption of vegetable oils has been linked to the progression of gum disease. These findings provide an additional explanation for the link between periodontal disorders and cardiovascular health.[24] It has been suggested that lipids derived from dairy products may reduce demineralization by forming a protective layer on the tooth enamel surface. Conversely, inadequate lipid intake may have negative effects on oral development and health. Lipid deficiency is associated with various clinical outcomes, including inflammatory oral diseases, degenerative pathologies, parotid gland swelling, associated decreased salivation, glandular parenchymal degeneration, and impaired mucosal trophism.[36] A recent consensus report published by the European Federation of Periodontics comprehensively evaluated the effects of micronutrients on periodontal health. It concluded that vitamin C deficiency contributes to the onset and progression of periodontal disease.[37] Vitamin C is a micronutrient essential throughout life for the regeneration of bones, teeth, and connective tissues. Inadequate vitamin C intake can lead to deficiency diseases such as scurvy, one of the earliest symptoms of which is gingivitis. As vitamin C deficiency progresses, collagen synthesis is impaired, leading to weakened connective tissues. As a result, wound healing is delayed, inflammation and bleeding of the gums occur, and loosening of teeth can occur due to weakened connective tissues. Ascorbic acid supplementation has been reported to have positive effects on the protection and improvement of periodontal health.[32] Gokhale et al. [38] observed that vitamin C supplementation or fruit consumption reduced gingival bleeding in patients with gingivitis and chronic periodontitis with diabetes. Trevisanato et al. [39] and Hassani et al. [40] demonstrated that green tea can inhibit the proliferation of Streptococcus species, prevent bacterial adherence to the tooth enamel surface, and provide a protective effect against dental caries by inhibiting glucosyltransferase and amylase enzymes. Probiotics play a crucial role in naturally colonizing the oral cavity and mitigating the harmful effects of pathogenic microorganisms. Regular probiotic consumption is beneficial in the prevention and treatment of various oral diseases, including dental caries, periodontitis, gingivitis, halitosis, and Candida infections. The most used microorganisms in oral probiotic preparations include Lactobacillus bulgaricus, Lactobacillus acidophilus, Lactobacillus casei, Lactobacillus helveticus, Lactococcus lactis, Lactobacillus salivarius, Lactobacillus plantarum, Streptococcus thermophilus, Enterococcus faecium, E. faecalis, Bifidobacterium species, and the Saccharomyces genus.[41,42] Moreover, polyphenols, phytates, and phosphates found in unprocessed plant foods are considered

anticariogenic compounds because they prevent bacterial plaque formation by reducing acid production in the oral environment.[43]

CONCLUSION

Oral health is a critical health indicator that affects overall health and quality of life. In this context, the frequent consumption of cariogenic foods is one of the main factors that negatively impacts oral health by creating an acidic environment and contributing to tooth decay, periodontal disease, and dental erosion. Scientific findings show that high sugar intake increases the oral microbial load, lowers salivary pH, and accelerates the destruction of dental tissues, while inadequate protein, vitamin, and mineral intake weakens periodontal defenses.

To protect oral health, individuals should limit the frequency of sugary and acidic food consumption, prefer water and milk over sweetened beverages, and include more high-fiber fruits, vegetables, and dairy products with anticariogenic properties in their diets. Regular dental check-ups and nutrition counseling should also be encouraged, particularly for individuals at higher risk. Multidisciplinary collaboration among nutritionists and dentists can further support effective preventive strategies and improve oral health outcomes.

Ethical Approval

An ethics statement was not required for this study type and no human or animal subjects or materials were used.

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Conflict of Interest

The authors deny any conflicts of interest related to this study.

Author Contributions

Design: MAÜ, MİP, Data collection or access: MAÜ, Analysis and comments: MAÜ, MİP, Mİ, Literature search: MAÜ, Writing: MAÜ, MİP, Mİ.

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