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Short communication

From salivary spectra to biochemical meaning: a practical biomarker framework for tobacco exposure

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Introduction

Tobacco exposure has a direct impact on the oral cavity, making saliva a biologically relevant and easily accessible matrix for assessing exposure-related biochemical changes. In smokers, saliva may reflect disturbances in redox balance, inflammatory activity, mucosal defense mechanisms and the composition of proteins, lipids, metabolites and inorganic ions. Current evidence indicates that smoking is associated with measurable alterations in salivary composition and function, supporting the relevance of saliva as a dynamic matrix for assessing tobacco-related biochemical effects (Zięba et al., 2022).

Fourier-transform infrared (FTIR) and Raman spectroscopy are increasingly used for saliva analysis because they provide label-free vibrational fingerprints of the molecular composition of the sample. These techniques can capture changes in protein, lipid, carbohydrate and low-molecular-weight components from relatively small sample volumes. However, their translational value depends not only on differentiating smokers from non-smokers, but also on assigning spectral changes to plausible biological processes and supporting them with targeted biochemical markers (Ferreira et al., 2025; Hardy et al., 2022). The aim is to synthesize available evidence on tobacco-related salivary spectral changes into a biomarker framework that supports their biochemical interpretation.

Salivary biochemical responses to tobacco exposure

Tobacco exposure may influence saliva through several interconnected biochemical domains. The oxidant burden of tobacco smoke can disturb the balance between reactive oxygen/nitrogen species and antioxidant defenses, reflected by altered total antioxidant capacity, lipid peroxidation products and thiol-dependent redox status (Kurtul and Gökpınar, 2012). In parallel, irritation of the oral mucosa may promote low-grade inflammatory activity and changes in mucosal protection. This response may involve salivary cytokines, chemokines, neutrophil-derived enzymes and matrix-remodeling proteins, which can provide targeted biochemical anchors for spectral interpretation. Saliva contributes to this protection through mucins, peroxidase activity and the thiocyanate/peroxidase system, all of which may be affected by chronic exposure (Rodrigues et al., 2017; Taniguchi et al., 2013). These biochemical domains provide the basis for interpreting spectral changes in saliva.

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Spectral domains and their biochemical interpretation

Tobacco-related salivary changes have mainly been described in spectral regions associated with proteins, lipids, carbohydrates/glycoproteins and thiocyanate. Alterations in the amide I/II regions may reflect changes in protein composition, conformation or oxidative modification, while Raman bands related to disulfide bonds have been linked to structural changes in salivary mucins (Taniguchi et al., 2013). Lipid-related features, particularly the ester carbonyl region around 1735–1750 cm^{-1} and CH_2/CH_3 stretching bands, are consistent with oxidative lipid alterations and align with reports of lipid peroxidation in smokers' saliva (Kurtul and Gökpınar, 2012; Rodrigues et al., 2017). The carbohydrate/glycoprotein fingerprint region may reflect changes in mucin glycosylation and salivary glycoprotein composition.

Among exposure-related markers, thiocyanate is particularly relevant because it produces a relatively isolated signal around 2058–2068 cm^{-1} and is increased in smokers, linking spectral detection with the salivary peroxidase defense system. A practical interpretation of salivary spectra should therefore combine spectral domains with targeted biochemical markers rather than rely only on pattern recognition. In this context, oxidative stress markers, inflammatory mediators, mucosal-defense components and exposure-related analytes represent complementary domains rather than isolated endpoints. Protein- and mucin-related spectral changes may be interpreted together with inflammatory markers, lipid- and CH-related bands with redox markers, and the thiocyanate band with biochemical exposure assessment. This framework improves biological interpretability by treating spectral domains as response patterns supported by targeted biomarkers, rather than as purely statistical classifiers (Rodrigues et al., 2017; Flieger et al., 2019).

Conclusion and translational perspective

Salivary FTIR and Raman spectroscopy provide a promising approach for detecting tobacco-related biochemical changes in saliva. The most informative spectral regions appear to correspond to protein and mucin alterations, lipid oxidation, carbohydrate/glycoprotein composition and thiocyanate accumulation. Their value, however, depends on linking spectral patterns with targeted biomarkers of oxidative stress, inflammation, mucosal protection and exposure. Standardized saliva collection, transparent spectral processing and biochemical confirmation remain necessary before these approaches can be translated into non-invasive screening or research applications. Such an approach may support future studies aimed at developing low-cost, non-invasive tools for monitoring tobacco-related biochemical effects in saliva.

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