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SYSTEMATIC REVIEW OPEN ACCESS

Evaluating the role of Salivary α-Amylase and Associated Enzymes in Carbohydrate Digestion and Gastrointestinal Function: A Comprehensive Systematic Review Perspective

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ABSTRACT

Background: Salivary *α*-amylase, sucrase, lactase, and maltase enzymes demonstrate an important role in carbohydrate metabolism and gastrointestinal function. Changes in enzymatic activity impact starch digestion, gut fermentation, insulin sensitivity, and digestive health. This systematic review aimed to evaluate how salivary *α*-amylase, sucrase, lactase, and maltase levels influence metabolic outcomes, carbohydrate digestion, and gastrointestinal functions. **Methods:** This systematic review followed PRISMA guidelines 2020. Research was conducted in PubMed, Scopus, Web of Science, and Google Scholar from 2016 to 2025. The studies involving salivary *α*-amylase, sucrase, lactase, and maltase activities in relation to metabolic and gastrointestinal outcomes were included. Non-human research or studies lacking outcome measurements were excluded. The appropriate tools were used for evaluating risk of bias according to the study designs whereas, quality of study was evaluated using GRADE approach. **Results:** The included eleven studies revealed that higher levels of salivary *α*-amylase, sucrase, lactase, and maltase were linked to improved gastrointestinal functions, such as greater insulin sensitivity and a lower risk of obesity. The risk of bias of most studies was measured as low to moderate and GRADE rated certainty of evidence as moderate. **Conclusion:** Salivary *α*-amylase, sucrase, lactase, and maltase activities might be useful indicators of metabolic health and digestion. Additional research is needed to clarify their use in clinical applications and personalized nutrition.

Keywords: Salivary *α*-Amylase, Disaccharidase, Carbohydrate Metabolism, Gastrointestinal Disorders, Systematic Review, Metabolic Health

Digestive enzymes particularly salivary α-amylase (sAA), sucrase, lactase, and maltase had a significant influence on carbohydrate digestion processes such as, activation of starch hydrolysis, postprandial glycemic responses, and overall gastrointestinal functions [1,2]. The variations in enzymatic activity, including disaccharidases directly affect the metabolism of carbohydrates and range of gastrointestinal symptoms and disorders such as irritable bowel syndrome [3-5]. Recent scientific interests are focused on the metabolic modulation mechanisms of genetic and phenotypic variation in digestive enzymes to insulin sensitivity, the development of obesity and diabetes, and functional gastrointestinal health [6,7]. Advancements in personalized nutrition and clinical diagnostics, would allow healthcare professionals to identify an individual in risk of metabolic dysfunction or digestive disease, and to tailor dietary and therapeutic interventions [8].

Translation of these findings into everyday clinical practice had become a challenging task due to small samples, heterogenic study designs, and the interplay between genetic vulnerabilities, food habits, and the environment [9]. The inconsistent correlation between the enzyme deficiencies and symptomatic expression was another issue that complicates the diagnosis and treatment [10]. Due to lack of existing evidence further studies are required to better understand the association between digestive enzyme and metabolic health. This systematic review established the role of sAA, sucrase, lactase, and maltase in digestive and gastrointestinal processing of carbohydrates. The review aimed to clarify the relationships between the enzyme activity, metabolic health, and digestive outcomes, to guide personalized nutritional and gastroenterological interventions by synthesizing evidence from interventional, observational, and cohort studies.

Methodology

The systematic review followed PRISMA 2020 guidelines to explore the impact of sAA, sucrase, lactase, and maltase levels on carbohydrate metabolism and gastrointestinal activity [11].

Data Sources and Search Strings used: The authors selected research published from 2016 to September 2025 by using databases i.e., PubMed, Scopus, Web of Science, and Cochrane Library. The search terms included MeSH terms and free-text words related to enzymatic activities such as "digestive enzymes," "salivary alpha-amylase," "carbohydrate metabolism," "obesity," "insulin sensitivity," "gastrointestinal symptoms," and "disaccharidase deficiency". Boolean operators (AND, OR) were also used, and reference lists of included studies were also screened to identify further eligible articles.

Inclusion and Exclusion Criteria: The criteria for included studies were human-based studies elucidating the levels of sAA, sucrase, lactase, or maltase on carbohydrate metabolism and gastrointestinal activity. Research papers based on case reports, reviews, and editorials were eliminated. Studies that were published in English were only taken into consideration. The excluded studies were non-human research articles and studies that failed to provide association between digestive enzymes, including salivary α-amylase, sucrase, lactase, and maltase levels, and gastrointestinal activity.

Study Screening and Data Extraction: Two independent reviewers carefully screened each study on the basis of title and abstract. Eligible studies were then assessed for full-text availability. Any disagreement was resolved by mutual discussion or by consulting to a third reviewer. Two independent reviewers performed data extraction, which included information about study design, sample size, confounding variables, outcome measures, and key results. The reviewers either achieved consensus or consulted a third person to settle any differences between their findings.

Quality Assessment: Assessment of risk of bias was made through ROBINS-I tool for observational and non-randomized interventional studies, RoB-2 for randomized control trials (RCTs), and AXIS tool for cross-sectional studies [12]. The level of evidence among studies was determined using GRADE approach.

Results

The study demonstrated the role of sAA, sucrase, lactase, and maltase levels on carbohydrate metabolism and gastrointestinal activity. Among the searched electronic databases and other sources, 114 research articles were initially selected. The number was reduced to 92 records after removing the duplicates. Title and abstract screening further eliminated 30 studies. From the remaining 62 articles, 21 were removed due to restricted access to the full-texts. Further 41 articles were screened, and 30 were eliminated as studies included animals, in vitro findings, reviews, case reports, or languages other than English. Ultimately, 11 studies that passed the inclusion criteria were included in this study. The PRISMA flow diagram illustrates the selection process (Figure 1). Table 1 summarized the characteristics of the articles incorporated into this systematic review including study design, study sample size, the confounders, and outcomes as well as the main findings. The diversity of the evidence presented in the table was methodological and included randomized controlled trials, as well as observational studies of different types in a metabolic and gastrointestinal context. It allowed the comparison of sAA and other digestive in various populations.

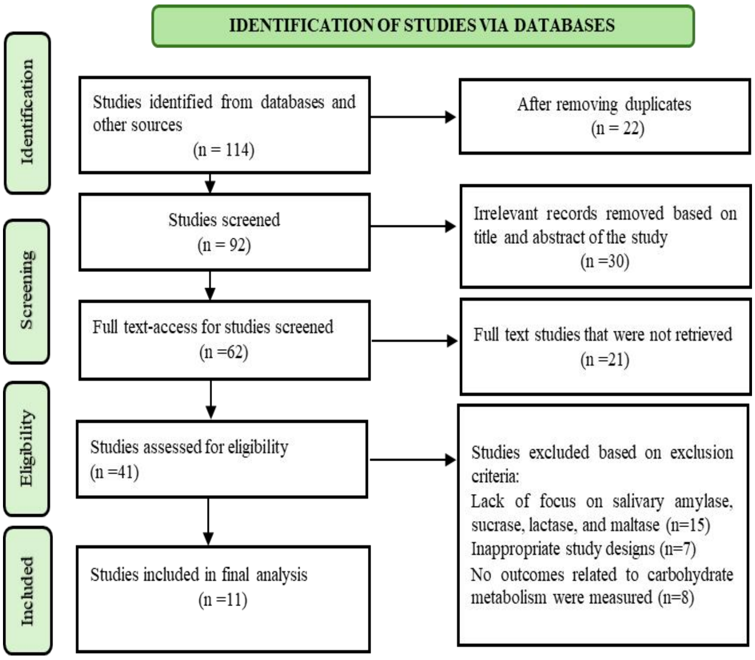

Figure 1: PRISMA Flow Diagram for Study Selection Process

Table 1: Characteristics and Key Findings of Individual Study Included in Systematic Review

Author & Year	Sample Size	Study Design	Confounders	Outcomes Measured	Key Findings
Erta et al., 2024 [13]	67	Randomized Control trial (12-week dietary intervention with randomization)	Age, BMI, hormonal cycle, dietary adherence	sAA activity, serum butyrate, insulin sensitivity	Higher salivary amylase activity is linked to improved insulin sensitivity, underlining its potential to be used as a biomarker for metabolic health.

Al-Akl et al., 2022 [14]	1499	Cross-sectional observational study	Age, sex, BMI, blood lipids, blood pressure	sAA activity, AMY1 copy number, obesity (BMI), diabetes markers	Higher salivary amylase activity was linked to a lower chance of obesity, but not to diabetes.
Tan et al., 2016 [15]	75	Randomized crossover trial	Ethnicity, particle size, mastication rate, gastric emptying	sAA activity, Glycemic response, mastication parameter	The number of chews mattered more than a person's amylase levels or genes, and no correlation was observed between ethnic groups.
Dbar et al., 2021 [16]	82	Prospective observational study	Use of NSAIDs, antibiotics, history of enteric infection, stress, diet triggers	Activity of glucoamylase, maltase, sucrase, lactase in duodenal biopsies	Digestive enzyme deficiencies, particularly lactase and glucoamylase, were common and were associated with bowel symptoms.
Deb et al., 2021 [17]	625	Retrospective cohort	Histology, age, ethnicity, symptom presentation	Sucrase, lactase, maltase, isomaltase, glucoamylase activities, SI gene variants	A genetic anomaly was found in 29% of abnormal sucrase cases, which often misdiagnosed due to their co-existence with other deficiencies
Dale et al., 2024 [18]	40	Single-center, prospective, observational	Age, BMI, small intestinal histology (e.g., celiac disease)	GI symptoms (IBS-SSS), IBS diagnosis, lactase, maltase, isomaltase, glucoamylase activities	Digestive enzyme deficiencies were common (60%) and were not linked to gastrointestinal symptoms or IBS.
Kemple et al., 2025 [19]	496	Retrospective cross-sectional	Age, sex, BMI, ethnicity	GI symptoms, lactase, sucrase, maltase or glucoamylase activities	Enzyme deficiency was not linked to any specific symptoms, though lactase deficiency varied by race.
Viswanathan et al., 2020 [20]	120	Retrospective cross-sectional	Age, sex, diabetes, PPI use, prior GI surgery	GI symptoms, lactose breath test (LBT), lactase, sucrase, maltase activities	47% of patients had an enzyme deficiency (mostly lactase), but no association between symptoms and prognosis was found.
Colombo et al., 2021 [21]	Not specified (pediatric cohort)	Retrospective, single-site	Age, sex, pain duration, duodenal inflammation	Lactase, sucrase, maltase or palatinase activities, Abdominal pain symptoms, food intolerances	Symptoms alone could not predict lactose deficiency, patients with dairy intolerance were more likely to be deficient.
Erta et al., 2025 [22]	67	Cross-sectional observational	Age, BMI, physical activity, dietary intake	Salivary amylase activity, Visceral fat (VF%), Triglyceride-Glucose (TyG) index	Salivary amylase improved insulin resistance primarily by reducing visceral fat, accounting for 45% of its effect.
Erta et al., 2024 [23]	67	Retrospective observational study	Age, BMI, diet adherence monitored	sAA, GLP-1, glucagon, C-peptide, leptin, triglycerides, visceral fat	Calorie restriction improved insulin sensitivity, but a low-starch diet worked better for raising a key gut hormone in people with low salivary amylase.

BMI = Body Mass Index; sAA = Salivary Alpha-Amylase; GI = Gastrointestinal; AMY1 = Amylase 1 (gene); NSAIDs = Non-Steroidal Anti-Inflammatory Drugs; SI gene variants =Sucrase-Isomaltase gene variants; IBS-SSS = Irritable Bowel Syndrome-Symptom Severity Scale; LBT = Lactose Breath Test; VF =Visceral Fat; TyG = Triglyceride-Glucose; PCA = Principal Component Analysis; GLP-1 =Glucagon-Like Peptide-1

The included studies suggested a positive association between sAA and associated digestive enzymes, namely lactase, sucrase and maltase, with a metabolic and gastrointestinal regulation. Interventional and observational data were consistent and revealed that increased salivary levels of α-amylase were related to greater insulin sensitivity and decreased adiposity which might be responsible to a contributory effect in metabolic regulation in the absence of key confounders. Population-based studies revealed that these digestive enzymes are directly linked to obesity-associated consequences rather than overt diabetes. Conversely, studies that assessed the intestinal disaccharidase activity showed that there was a high rate of enzymes deficiencies across age groups, but poor correlation of biochemical deficiency with gastrointestinal symptoms was observed. Genetic and histological reports of frequent comorbid deficiencies and ethnic heterogeneity had further complicated the diagnosis.

The experimental evidence revealed that behavioral variables (mastication) could surpass enzymatic variability in the acute responses to glucose levels. Comprehensively, the results suggested context-dependent functions of digestive enzymes, with sAA mainly correlated with metabolic adjustments and intestinal enzymes indicating the potential of the digestive capacity and not the symptom burden. The Cochrane RoB2 tool was used to assess risk of bias in RCTs-based study (Table 2).

Table 2: Risk of Bias in Randomized Controlled Trials (Cochrane RoB 2)

Domains	**Erta et al., 2024 [13]**
Bias arising due to randomization process	Low
Bias due to deviations from intended interventions	Low
Bias due to missing outcome data	Low
Bias in measurement of the outcome	Low
Bias due to selection of the reported result	Low
Overall Risk of Bias	Low

All the domains that were evaluated such as randomness, adherence to the intervention, completeness of the outcome data, outcome measurement, and reporting were categorized as low risk. As a result, the general risk of bias of the study conducted by Erta et al., 2024 [13] was regarded as low, implying good methodological quality. Table 3 represents the quality assessment of included observational studies based on the Newcastle-Ottawa Scale.

Table 3: Risk of Bias Assessment of Observational Studies (Newcastle-Ottawa Scale)

Study	**Selection (0–4)**	**Comparability (0–2)**	**Outcome (0–3)**	**Total Score (0–9)**
Dbar et al., 2021 [16]	★★★	★	★★★	7
Deb et al., 2021 [17]	★★★	★	★★★	7
Dale et al., 2024 [18]	★★★	★	★★★	7
Kemple et al., 2025 [19]	★★★	★	★★★	7
Viswanathan et al., 2020 [20]	★★★	★	★★★	7
Colombo et al., 2021 [21]	★★★	★	★★★	7
Erta et al., 2024 [23]	★★★	★	★★★	7

The scores were consistent in all studies with high level of selection and outcome and moderate comparability, thus a total score of 7 out of 9 was gained. This shows a moderate-to-high level of the methodological quality in the included research. AXIS tool was used to measure risk of bias among cross-sectional studies as shown in Table 4.

Table 4. Risk of Bias Assessment of Cross-Sectional Study (AXIS)

AXIS Domain	**Al-Akl et al., 2022 [14]**	**Erta et al., 2025 [22]**
Clear study objectives	Yes	Yes
Appropriate study design	Yes	Yes
Sample size justification	Yes	Yes
Representative target population	Partial	Partial
Valid and reliable measurement tools	Yes	Yes
Appropriate statistical analysis	Yes	Yes
Non-response bias addressed	No	No
Ethical approval reported	Yes	Yes
Funding/conflict of interest stated	Yes	Yes
Overall Risk of Bias	Moderate	Moderate

In both studies, the methodological quality was high in most areas, such as the study design, measurement validity, and statistical analysis, yet they were limited by the representativeness of the population and non-response bias. In general, the risk of bias in both studies was moderate. The risk of bias measurement on the non-randomized interventional study was summarized as presented in Table 5 using the ROBINS-I tool.

Table 5. Risk of Bias Assessment of Non-Randomized Interventional Study (ROBINS-I)

Domain	**Tan et al., 2016 [15]**
Bias due to confounding	Moderate
Bias during selection of participants	Low
Bias in classification of intervention	Low
Bias due to deviations from intended intervention	Low
Bias due to missing data	Low
Bias in measurement of outcomes	Low
Bias in selection of reported results	Low
Overall Risk of Bias	Moderate

Although the majority of the domains presented a low risk of bias, moderate levels of bias as a result of confounding were found. Generally, the study was rated as a moderate risk of bias, and it had certain internal validity limitations. The certainty of evidence was rated as moderate using GRADE assessment.

Discussion

This systematic review confirmed that salivary α-amylase, sucrase, lactase, and maltase concentrations had a major impact on both metabolic and gastrointestinal wellbeing. The collected evidence suggested that an increase in sAA activity led to increase in insulin sensitivity, decrease in obesity risk, and positive metabolic results [24-27]. Likewise, adequate levels of essential disaccharidases, including lactase, sucrase and glucoamylase are also critical in the effective digestion of carbohydrates and could prevent malabsorptive gastrointestinal symptoms [28,29]. The metabolic advantages, in addition to lessening functional digestive discomfort, were observed in patients with strong enzymatic activity [30]. SAA, sucrase, lactase, and maltase activities were essential and determined the efficiency of initial starch digestion which subsequently affects the postprandial glycemic responses and availability of substrate to fermentation by gut microbes [31,32]. This enzymatic instigate might be one of the causes of the individual differences in metabolic processing of carbohydrates and also in predisposition to other diseases such as type 2 diabetes [33].

The studies indicated that people having elevated sAA activity have superior glycemic regulation and reduced adiposity indicators, especially when the dietary carbohydrate content is controlled [34,35]. This association highlights that the enzyme act as a nutrient metabolism modulator. Experimental studies further support the role of biochemical modulators in influencing metabolic homeostasis and disease risk [36,37]. The disaccharidase deficiencies were also highly expressed in the gastrointestinal health, but the correlation between the enzyme deficiency and any particular clinical symptoms were rather weak and inconsistent [38]. Although enzyme deficiencies such as lactase were prevalent, but the symptoms of intolerance or functional bowel disorders in individuals could not be identified [39]. This implied that the symptomatic manifestation of enzyme insufficiencies could be mediated by specific factors such as microbiome composition of the gut, intestinal sensitivity, dietary habits, and efficiency of mastication [40,41].

Despite the fact that sAA, sucrase, lactase, and maltase were important contributors to metabolic and digestive health, associated studies have severe limitations that limit conclusive results. Heterogeneous study designs, large range of sample sizes, disparity in dietary assessment and deficiency of standardized means of measuring enzyme activity impedes the formation of clear causal relationships. The findings showed a high degree of clinical and methodological heterogeneity that might be due to different population features, environmental factors, lifestyle and intricate diet-gene-microbiome interactions [42]. Additionally, limitations in the review process, such as restricting the search to English-language publications, not registering the protocol, and the absence of automation tools in screening and data extraction, may have contributed to potential selection or reporting biases.

Further studies are needed to establish standardized, clinically useful techniques of measuring the digestive enzyme profiles as well as elucidating their relationships with diet and lifestyle factors. To ascertain these associations and to study the predictive power of enzyme activity with regards to metabolic and digestive disorders, longitudinal and more strictly controlled studies are required. Incorporation of enzyme activity measurement into both prophylactic and therapeutic measures might lead to more efficient and specific intervention of the at-risk population in case of metabolic dysfunction or chronic diseases of the gastrointestinal tract.

Conclusion

The systematic review demonstrated that sAA, sucrase, lactase, and maltase activities were significant predictors of carbohydrate metabolism and gastrointestinal health. The presence of these enzymes in the body was associated with the regulation of metabolism and digestion, and thus can be the subject of biomarkers of personalized dietary and gastroenterological treatment. Future research needed to standardized reference ranges and explore their interaction with diet and the gut microbiome. This would result in the development of more specific nutritional interventions and better diagnostic pathways in gastroenterology.

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Conflict of Interest: None

Authors' Contribution: NA and ZT participated in conception and design of the study, data analysis and interpretation, and statistical analysis. MT participated in collection and assembly of data, data analysis and interpretation. FA participated in article writing and statistical analysis. MA critically reviewed the article and participated in statistical analysis. EEK participated in article writing and statistical analysis. KU revised the article and performed statistical analysis. All authors gave their final approval to publish this article.

Ethical Statement: Not applicable for this study design

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