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Research Article

Gut Enzyme Activity and Its Influence on Intestinal Morphology and Nutrient Absorption Efficiency

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ABSTRACT

Background: Gut enzymes play a crucial role in gut function and nutrient absorption. Changes in gut enzyme activity could affect the intestinal structure and efficiency of nutrient absorption, resulting in gastrointestinal and nutritional disorders. The present research was designed to assess the activity of gut enzymes and their effect on intestinal structure and efficiency of nutrient absorption in adults.

Methods: The study was an analytical cross-sectional study, which was carried out at Pak International Medical College between January 2025 and January 2026. Seventy-two patients were enrolled via consecutive non-probability sampling. Data collected demographic details, clinical features, digestive enzyme levels, intestinal structural and nutrient absorption related factors. Microscopic assessment was conducted on the height and depth of the villi and crypts, mucosal thickness, and epithelial integrity. Data analysis was performed with IBM SPSS Statistics 26. Pearson's correlation and multiple linear regression methods were used to assess relationships.

Results: The mean age of participants was 36.9 ± 10.8 years, with females representing the majority of the study population. Amylase and alkaline phosphatase demonstrated comparatively higher activity levels, while lactase activity was lower among several participants. Histological examination showed variations in villus height, crypt depth, and epithelial integrity. Significant positive correlations were observed between digestive enzyme activity and nutrient absorption efficiency. Reduced villus height, lower lactase activity, and impaired epithelial integrity were identified as significant predictors of decreased nutrient absorption efficiency.

Conclusion: Gut enzyme activity showed a strong association with intestinal morphology and nutrient absorption efficiency. Reduced digestive enzyme levels and structural intestinal alterations were linked with impaired nutritional absorption. Early recognition of intestinal enzymatic dysfunction may help improve gastrointestinal and nutritional health outcomes.

Keywords: Gut enzymes; intestinal morphology; nutrient absorption; digestive enzymes; villus height; gastrointestinal function

INTRODUCTION

Digestion, absorption, and nutritional homeostasis are vital functions of the gastrointestinal tract. Normal digestion requires optimal activity of digestive enzymes secreted by the intestinal mucosa and other digestive organs. They break down carbohydrates, proteins and fats into small molecules that can be absorbed by the body for use in growth, metabolic processes and tissue regeneration. Alterations in digestive enzyme activity can affect nutrient absorption and lead to dysfunction of the intestines (1-3).

Lactase, maltase, sucrase, amylase, lipase and protease are some of the key enzymes involved in the digestion process. Lack or decreased activity of these enzymes have been linked to malabsorption, chronic diarrhea, flatulence, abdominal pain and malnutrition. Impaired enzymatic digestion may also impact the intestinal environment and integrity of the intestinal mucosa. There is evidence that links

changes in digestive enzymes to intestinal damage in several gastrointestinal diseases (3-5).

Intestinal structure also plays an important role in determining nutrient absorption. The efficiency of intestinal absorption is influenced by the intestinal structure, such as the height of the villi, the depth of the crypts, the thickness of the mucosa, the number of goblet cells, and integrity of the epithelium. Destructive changes to the small intestinal villi decrease the absorptive surface area and can hinder the transportation of nutrients across the intestinal barrier. Changes in the structure of the intestinal mucosa have been reported in inflammatory, infectious, metabolic and nutritional diseases of the digestive system (6-8).

Recent research has emphasised the interplay between digestive enzyme activity and intestinal structure in preserving intestinal nutrient absorption. Impaired enzyme activity may lead to mucosal damage and intestinal inflammation and villus damage may also affect enzyme secretion and nutrient transport. While there is increasing recognition of the importance of intestinal physiology and digestive health, few local studies have described the association between intestinal enzyme activity, intestinal structure and efficiency of nutrient absorption in adults (9, 10).

Therefore, the present study was conducted to evaluate gut enzyme activity and its influence on intestinal morphology and nutrient absorption efficiency among participants attending a tertiary care medical institution. The findings may contribute to a better understanding of gastrointestinal functional health and assist in early identification of factors associated with impaired nutritional absorption.

METHODOLOGY

This analytical cross-sectional study was conducted at Pak International Medical College from January 2015 to January 2016. The purpose of the study was to assess the activity of intestinal enzymes and its association with intestinal structure and absorption of nutrients in adult patients with gastrointestinal symptoms or nutritional disorders.

Using a consecutive non-probability sampling method, 72 participants were recruited. The sample size was calculated using the WHO sample size estimation technique, with 95% confidence level and expected variability in enzyme activity, as per previous research. Both men and women aged 18 years and over were recruited. Participants with severe systemic disease, cancer, chronic liver disease, history of intestinal surgery or those taking medications that directly affect intestinal enzyme activity were excluded.

Following informed consent, patients were assessed using a questionnaire and demographic data collected. Data on age, sex, body mass index, dietary patterns, gastrointestinal symptoms and medical history were recorded. Blood and stool samples were collected in a laboratory setting for assessment of digestive enzyme function and nutritional status.

Gut enzymes such as lactase, sucrase, maltase, lipase, protease, amylase and alkaline phosphatase were evaluated using commercially available enzyme assay kits. Nutritional absorption was measured using biochemical markers such as serum albumin, haemoglobin, iron indices, calcium, vitamin B12, and protein absorption indices.

Intestinal morphology was evaluated by histopathological analysis of intestinal mucosal biopsy samples, if applicable. 'Histopathologists assessed the intestinal morphology, including villus height, crypt depth, villus-to-crypt ratio, goblet cell density, mucosal thickness, and epithelial integrity'.

Data was entered and analysed using IBM SPSS Statistics software version 26. Numerical data were expressed in terms of mean and standard deviation, while categorical data were expressed in terms of frequency and percentages. Bivariate correlation analysis was used to assess associations between enzyme activity, gut structure and nutrient absorption. Logistic regression was used to determine factors that predict low nutrient absorption efficiency. A p-value of less than 0.05 was used for statistical significance.

RESULTS

The researchers studied 72 participants for gastrointestinal enzyme activity, intestinal structure, and absortptive capacity. Enzyme activity variations were found in conjunction with morphological changes, which affected nutrient absorption.

Table 1: Demographic and Clinical Characteristics of Participants (n=72)

Variables	Frequency (n)	Percentage (%)
Age Group		
18–30 years	21	29.2
31–45 years	34	47.2
Above 45 years	17	23.6
Gender		
Male	31	43.1
Female	41	56.9
BMI Category		
Normal weight	24	33.3
Overweight	29	40.3
Obese	19	26.4
Dietary Pattern		
Mixed diet	46	63.9
Predominantly carbohydrate-based diet	18	25.0
High-protein diet	8	11.1
Gastrointestinal Symptoms		
Abdominal discomfort	27	37.5
Bloating	19	26.4
Diarrhea	14	19.4
No major symptoms	12	16.7

Evaluation of digestive enzymes revealed variations among subjects, especially those digesting carbohydrates and fats.

Table 2: Gut Enzyme Activity Levels among Participants

Enzyme Parameters	Mean ± SD
Lactase activity (U/L)	28.6 ± 6.2
Sucrase activity (U/L)	41.8 ± 8.7
Maltase activity (U/L)	52.4 ± 10.3
Lipase activity (U/L)	39.5 ± 7.4
Protease activity (U/L)	47.1 ± 9.2
Amylase activity (U/L)	61.7 ± 12.5
Alkaline phosphatase activity (IU/L)	76.2 ± 14.1

Histological analysis of the intestine revealed differences in villus structure and mucosal structure, reflecting variable intestinal health.

Table 3: Intestinal Morphological Findings

Morphological Parameters	Mean ± SD
Villus height (μm)	421.6 ± 58.3
Crypt depth (μm)	162.7 ± 29.4
Villus-to-crypt ratio	2.61 ± 0.48
Mucosal thickness (μm)	518.3 ± 66.9
Goblet cell count	18.5 ± 4.2
Intestinal surface area score	7.4 ± 1.6
Epithelial integrity score	6.9 ± 1.3

Biochemical and nutritional analyses showed moderate differences in nutrient absorption efficiency.

Table 4: Nutrient Absorption Efficiency Parameters

Parameters	**Mean ± SD**
Protein absorption (%)	73.8 ± 10.4
Fat absorption (%)	69.1 ± 11.2
Carbohydrate absorption (%)	81.6 ± 9.5
Iron absorption (µg/dL)	68.7 ± 13.8
Calcium absorption (mg/dL)	8.9 ± 1.1
Vitamin B12 level (pg/mL)	372.5 ± 74.3
Serum albumin (g/dL)	3.9 ± 0.5
Hemoglobin (g/dL)	12.4 ± 1.7

Biostatistical analysis showed significant associations between enzyme activity, intestinal structure and nutrient absorption efficiency.

Table 5: Correlation between Gut Enzyme Activity, Intestinal Morphology, and Nutrient Absorption

Variables Compared	**Correlation Coefficient (r)**	**p-value**
Lactase activity vs villus height	+0.48	0.002
Lipase activity vs fat absorption	+0.57	<0.001
Protease activity vs protein absorption	+0.51	0.001
Villus height vs carbohydrate absorption	+0.44	0.004
Crypt depth vs nutrient absorption efficiency	-0.39	0.009
Epithelial integrity vs serum albumin	+0.46	0.003

Multivariate regression analysis showed multiple independent factors were predictive of decreased nutrient absorption efficiency.

Table 6: Predictors of Reduced Nutrient Absorption Efficiency

Variables	**Odds Ratio (OR)**	**95% CI**	**p-value**
Reduced lactase activity	2.18	1.21–4.63	0.018
Decreased villus height	2.74	1.36–5.42	0.006
Increased crypt depth	1.93	1.11–3.88	0.031
Low epithelial integrity score	2.41	1.27–4.95	0.014
Obesity	1.68	0.92–3.41	0.087

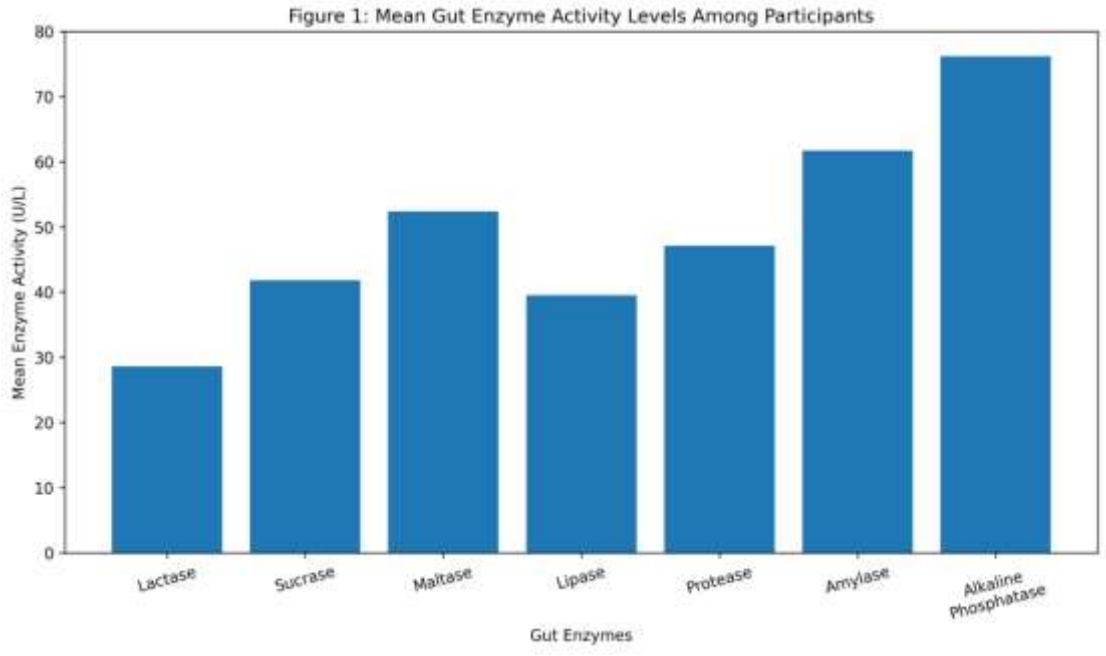

Figure 1: Mean Gut Enzyme Activity Levels Among Study Participants

This figure illustrates the average activity levels of major digestive enzymes evaluated in the study population. Alkaline phosphatase and amylase demonstrated comparatively higher mean activity levels, whereas lactase showed the lowest enzymatic activity among the assessed enzymes.

DISCUSSION

In this study, participants' intestinal enzyme activity was measured and related to intestinal structure and nutrient absorption efficiency. The results showed that intestinal digestive enzyme activity was linked to morphological changes in the mucosal membrane, resulting in decreased nutrient absorption. The group with reduced enzyme activity exhibited relatively poorer nutritional status, suggesting that intestinal enzymes play a significant role in promoting gastrointestinal function and nutritional balance (11-13).

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This study's histological analysis revealed differences in villus height, crypt depth, mucosal thickness, and epithelial integrity. Those with decreased villus height and increased crypt depth showed impaired nutrient absorption. These observations support prior studies of the gut which demonstrate that villus damage in the gut decreases surface area and impairs nutrient absorption. Intestinal wall malformations have been reported to play a significant role in malnutrition, chronic inflammation and gastrointestinal diseases (17).

The study also revealed strong positive associations between enzyme activity and indicators of nutrient absorption. Lipase activity was strongly associated with fat absorption and protease activity showed a positive correlation with protein absorption. These results suggest that digestive enzymes play a direct role in the digestion and absorption of nutrients in the gut. These results are consistent with recent metabolic and gastrointestinal research showing that enzyme deficiency is associated with decreased absorption of fats, proteins, vitamins and micronutrients (18, 19).

Another significant finding of the current study was the link between mucosal integrity and nutritional indices (e.g. albumin and hemoglobin). The biochemical nutritional status of participants with intact mucosal architecture was superior to that with mucosal injury. This indicates that both structural integrity and enzyme activity of the gut are integral in maintaining optimal nutritional status. Similar findings have been made in studies of chronic intestinal inflammation and enteropathy, in which mucosal disruption led to decreased nutrient absorption and metabolic dysfunction (20).

This study also showed that low lactase activity, villus height and epithelial integrity were independently associated with low nutrient absorption efficiency, using regression analysis. These observations underline the complex nature of intestinal dysfunction, and the need for healthy enzyme function and mucosal architecture. Thus, early recognition of digestive enzyme dysfunction and mucosal injury may help to avoid long-term nutritional complications and gastrointestinal health.

The current study has some strengths, such as the simultaneous assessment of biochemical enzyme activity, intestinal morphological changes, and parameters of nutritional absorption in the same population. But there are also limitations. The study population was small and single center, which may affect the generalizability of the results. This study also did not include long-term evaluation and molecular analysis of intestinal transport mechanisms. Multicenter studies with larger cohorts and longitudinal follow-up are suggested for investigation into digestive enzymes, intestinal morphology and nutritional status.

CONCLUSION

The findings of this study demonstrated that gut enzyme activity has a significant relationship with intestinal morphology and nutrient absorption efficiency. Reduced digestive enzyme levels were associated with structural intestinal alterations and impaired absorption of essential nutrients. Preservation of intestinal mucosal integrity and adequate enzymatic activity appears essential for maintaining optimal digestive and nutritional function. Early recognition of intestinal enzymatic dysfunction may help improve nutritional status and reduce gastrointestinal complications through timely clinical intervention.

REFERENCES

1. Miao Z, Liu Y, Guo L, Zhao W, Zhang JJA. Effects of dietary chitosan on growth rate, small intestinal morphology, nutrients apparent utilization and digestive enzyme activities of growing Huoyan geese. 2020;14(12):2635-41.
2. Li Y, Guo Y, Zhang C, Cai X, Liu P, Li CJA. Effects of physical forms of starter feed on growth, nutrient digestibility, gastrointestinal enzyme activity, and morphology of pre-and post-weaning lambs. 2021;15(1):100044.
3. Shi Z, Wang T, Kang J, Li Y, Li Y, Xi LJA. Effects of weaning modes on the intestinal pH, activity of digestive enzymes, and intestinal morphology of piglets. 2022;12(17):2200.
4. Li Z, Zhang B, Zhu W, Lin Y, Chen J, Zhu F, et al. Effects of nonantibiotic growth promoter combinations on growth performance, nutrient utilization, digestive enzymes, intestinal morphology, and cecal microflora of broilers. 2023;18(3):e0279950.
5. Dawood MA, Magouz FI, Salem MF, Elbialy ZI, Abdel-Daim HAJP, proteins A. Synergetic effects of Lactobacillus plantarum and β-glucan on digestive enzyme activity, intestinal morphology, growth, fatty acid, and glucose-related gene expression of genetically improved farmed tilapia. 2020;12(2):389-99.
6. Liu Y, Fan J, Huang H, Zhou H, Cao Y, Zhang Y, et al. High dietary non-starch polysaccharides detrimental to nutrient digestibility, digestive enzyme activity, growth performance, and intestinal morphology in largemouth bass, Micropterus salmoides. 2022;9:1015371.
7. Shang Q, Wu D, Liu H, Mahfuz S, Piao XJA. The impact of wheat bran on the morphology and physiology of the gastrointestinal tract in broiler chickens. 2020;10(10):1831.
8. Attia YA, Al-Khalaifah HS, Alqhtani AH, Abd El-Hamid HS, Alyileili SR, El-Hamid AE-HEA, et al. The impact of multi-enzyme fortification on growth performance, intestinal morphology, nutrient digestibility, and meat quality of broiler chickens fed a standard or low-density diet. 2022;9:1012462.
9. Xu F, Wu H, Xie J, Zeng T, Hao L, Xu W, et al. The effects of fermented feed on the growth performance, antioxidant activity, immune function, intestinal digestive enzyme activity, morphology, and microflora of yellow-feather chickens. 2023;13(22):3545.
10. Liu X, Huang X, Fu Y, Wang Y, Lu ZJFiP. The positive effects of exogenous pancreatin on growth performance, nutrient digestion and absorption, and intestinal microbiota in piglets. 2022;13:906522.
11. Youssef IM, Männer K, Zentek JJJoAP, Nutrition A. Effect of essential oils or saponins alone or in combination on productive performance, intestinal morphology and digestive enzymes' activity of broiler chickens. 2021;105(1):99-107.
12. Li Z, Zhang J, Wang T, Zhang J, Zhang L, Wang TJFiVS. Effects of capsaicin on growth performance, meat quality, digestive enzyme activities, intestinal morphology, and organ indexes of broilers. 2022;9:841231.
13. Alqhtani AH, Al Sulaiman AR, Alharthi AS, Abudabos AMJA. Effect of exogenous enzymes cocktail on performance, carcass traits, biochemical metabolites, intestinal morphology, and nutrient digestibility of broilers fed normal and low-energy corn–soybean diets. 2022;12(9):1094.
14. Attia GA, Metwally AE, Beheiry RR, Farahat MHJIJoAS. Effect of a multicarbohydrase supplementation to diets varying in metabolisable energy level on the performance, carcase traits, caecal microbiota, intestinal morphology, and nutrient digestibility in broiler chickens. 2021;20(1):215-25.
15. Zhu B-P, Zhou J, Wang Z, Hu Y, Cai M, Yang L, et al. Interactions between intestinal morphology, digestion, inflammatory responses, and gut microbiota of juvenile channel catfish elicited by dietary enzymatic rice protein. 2022;127:155-65.
16. Xie J, Wang Z, Cui H, Nie H, Zhang T, Gao X, et al. Effects of enzymatic hydrolysate of locust bean gum on digestibility, intestinal

morphology and microflora of broilers. 2020;104(1):230-6.
17. Popescu RG, Voicu SN, Gradisteanu Pircalabioru G, Gharbia S, Hermenean A, Georgescu SE, et al. Impact of dietary supplementation of flaxseed meal on intestinal morphology, specific enzymatic activity, and cecal microbiome in broiler chickens. 2021;11(15):6714.
18. Zhang C, Hao E, Chen X, Huang C, Liu G, Chen H, et al. Dietary fiber level improve growth performance, nutrient digestibility, immune and intestinal morphology of broilers from day 22 to 42. 2023;13(7):1227.
19. Madigan-Stretton J, Mikkelsen D, Soumeh EAJA. Multienzyme super-dosing in broiler chicken diets: The implications for gut morphology, microbial profile, nutrient digestibility, and bone mineralization. 2020;11(1):1.
20. Cheng Y, Ding S, Azad MAK, Song B, Kong XJM. Comparison of the pig breeds in the small intestinal morphology and digestive functions at different ages. 2023;13(1):132.