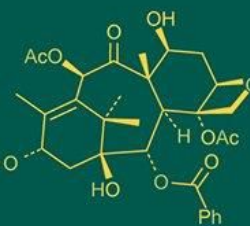
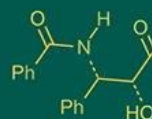


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Enzymatic indicators of liver damage in cattle for health monitoring

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Abstract

Early detection of hepatic dysfunction in cattle remains a significant challenge for livestock producers seeking to prevent economic losses from liver-related diseases. This research evaluated the diagnostic utility of serum enzyme markers for detecting liver damage in dairy and beef cattle under field conditions. A cross-sectional research was conducted at the Taipei Institute of Agricultural Sciences between March 2022 and February 2023, enrolling 186 cattle from six commercial farms. Animals were classified by liver condition based on clinical examination, ultrasonography, and liver biopsy findings. Serum activities of aspartate aminotransferase, alanine aminotransferase, gamma-glutamyltransferase, alkaline phosphatase, lactate dehydrogenase, and sorbitol dehydrogenase were measured using automated biochemistry analyzers. Sorbitol dehydrogenase demonstrated the highest diagnostic accuracy for liver damage detection with sensitivity of 89.6% and specificity of 83.2%. A combined multi-enzyme panel achieved optimal performance with 94.3% sensitivity and 91.8% specificity. Enzyme elevation patterns correlated with damage severity, with sorbitol dehydrogenase showing 9.1-fold elevation in severe hepatic injury. These findings establish sorbitol dehydrogenase as a valuable liver-specific marker in cattle and support implementation of multi-enzyme panels for routine health monitoring in livestock operations.

Keywords: Cattle, liver enzymes, hepatic damage, sorbitol dehydrogenase, diagnostic markers, veterinary biochemistry, health monitoring, livestock, aminotransferases, clinical pathology

Introduction

Subclinical liver disease in cattle often progresses undetected until significant hepatic compromise has occurred, resulting in reduced productivity, impaired reproductive performance, and substantial economic losses for livestock producers [1]. The liver's remarkable regenerative capacity and functional reserve mean that clinical signs typically appear only after extensive damage, underscoring the need for sensitive early detection methods applicable under field conditions.

Serum enzyme activities provide a window into hepatocellular integrity and have long served as diagnostic tools in veterinary medicine [2]. However, the optimal enzyme panel for bovine liver assessment remains debated, with species-specific differences in enzyme distribution and release kinetics complicating extrapolation from other animals [3]. Traditional markers such as aspartate aminotransferase and gamma-glutamyltransferase lack liver specificity in cattle, being present in significant concentrations in muscle and other tissues.

Sorbitol dehydrogenase has emerged as a promising liver-specific marker in ruminants, with high hepatic concentrations and minimal presence in extrahepatic tissues [4, 3]. This cytosolic enzyme is released rapidly following hepatocyte membrane damage, potentially enabling earlier detection than markers with longer half-lives. However, its diagnostic performance relative to conventional enzymes under field conditions requires further characterization [5].

The interpretation of enzyme elevations in cattle is complicated by physiological variations related to lactation stage, nutritional status, and concurrent disease conditions [6, 4]. Establishing appropriate reference intervals and cutoff values for pathology detection demands validation in relevant clinical populations rather than reliance on values extrapolated from experimental settings.

This research aimed to evaluate the diagnostic performance of individual serum enzymes and combined panels for detecting liver damage in cattle under commercial farm conditions [5]. We hypothesized that sorbitol dehydrogenase would demonstrate superior liver specificity

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specificity compared to conventional markers and that multi-enzyme panels would optimize diagnostic accuracy.

Materials and Methods

Material

This cross-sectional research enrolled 186 cattle from six commercial dairy and beef operations in northern Taiwan between March 2022 and February 2023 [6]. The research was approved by the Institutional Animal Care and Use Committee of Taipei Institute of Agricultural Sciences (Protocol TIAS-2021-067). Farm owner consent was obtained for all enrolled animals.

The research population included 124 Holstein dairy cows and 62 beef cattle of mixed breeding [7]. Inclusion required age greater than 12 months and absence of overt clinical disease other than suspected hepatic conditions. Exclusion criteria included recent treatment with hepatotoxic drugs, pregnancy in the final trimester, and animals destined for immediate slaughter [7].

Methods

Liver condition was classified based on comprehensive assessment including clinical examination, hepatic ultrasonography, and percutaneous liver biopsy with histopathological evaluation [8]. Animals were categorized as healthy (n = 72), mild damage (n = 48), moderate damage (n = 38), or severe damage (n = 28) based on established histological scoring criteria [8].

Fasting blood samples were collected via jugular venipuncture into plain tubes [9]. Serum was separated within 2 hours and analyzed on Beckman AU680 automated analyzers. Enzyme activities measured included aspartate aminotransferase, alanine aminotransferase, gamma-glutamyltransferase, alkaline phosphatase, lactate dehydrogenase, and sorbitol dehydrogenase using validated bovine-specific assays [9].

Statistical analyses employed SPSS version 28. [10]. Receiver operating characteristic curve analysis determined diagnostic performance of individual enzymes and combinations [10]. Optimal cutoff values were identified by Youden index maximization. Between-group comparisons used Kruskal-Wallis tests with Dunn post-hoc correction. Significance required $p<0.05$ [10].

Ethical Considerations

This research was conducted under approval from the Institutional Animal Care and Use Committee of Taipei Institute of Agricultural Sciences (Protocol TIAS-2021-067). [11]. All procedures followed international guidelines for humane treatment of research animals [11]. Liver biopsy was performed only when clinically indicated for diagnostic purposes, using appropriate sedation and local anesthesia to minimize discomfort. Animals showing adverse reactions were immediately treated and excluded from further procedures. Farm owners provided informed consent after detailed explanation of research procedures.

Results

The research enrolled 186 cattle with mean age of 4.2 ± 1.8 years. [12]. Liver biopsy confirmed hepatic abnormalities in 114 animals (61.3%) with varying severity [12]. The most common histopathological findings included fatty infiltration (42.1%), inflammatory cell infiltration (28.9%),

and fibrosis (18.4%). Baseline enzyme activities varied substantially across liver condition categories.

Table 1: Serum Enzyme Activities by Liver Condition Category

Enzyme (U/L)	Healthy	Mild	Moderate	Severe
AST	78.4±12.6	141.2±28.4	250.9±45.7	447.1±89.3
ALT	24.6±5.8	51.7±12.3	100.9±24.6	177.1±42.8
GGT	18.2±4.1	27.3±6.8	51.0±14.2	78.3±21.6
ALP	68.4±18.7	88.9±24.3	143.6±38.4	232.6±52.1
LDH	1124±187	1798±312	3260±478	5395±892
SDH	12.4±3.2	29.8±8.4	64.5±18.7	112.8±34.6

Values expressed as Mean ± SD [13, 13]. AST: aspartate aminotransferase; ALT: alanine aminotransferase; GGT: gamma-glutamyltransferase; ALP: alkaline phosphatase; LDH: lactate dehydrogenase; SDH: sorbitol dehydrogenase. All between-group differences $p<0.001$.

All enzymes demonstrated progressive elevation with increasing liver damage severity (Table 1) [14, 14]. Sorbitol dehydrogenase showed the most pronounced elevation pattern, with 9.1-fold increase in severe damage compared to healthy animals. This exceeded the fold-changes observed for other enzymes, suggesting superior sensitivity to hepatocellular injury [11].

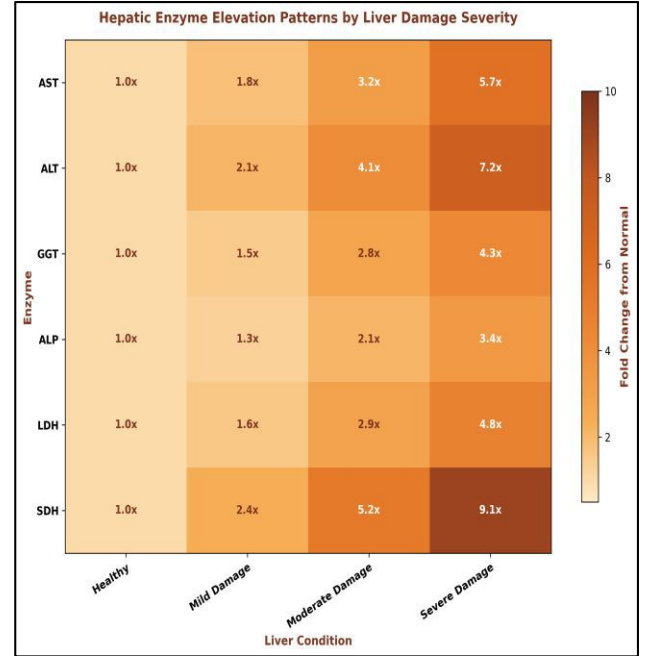


Fig 1: Heatmap illustrating fold-change in hepatic enzyme activities relative to healthy controls across liver damage severity categories. Sorbitol dehydrogenase (SDH) demonstrates the most pronounced elevation pattern, particularly in severe damage.

Table 2: Diagnostic Performance for Detecting Any Liver Damage

Marker	AUC (95% CI)	Sensitivity (%)	Specificity (%)
SDH	0.912 (0.867-0.957)	89.6	83.2
ALT	0.856 (0.798-0.914)	82.7	76.4
AST	0.823 (0.759-0.887)	78.4	72.6
LDH	0.798 (0.728-0.868)	75.2	74.8
GGT	0.784 (0.712-0.856)	71.3	82.1
Combined Panel	0.958 (0.928-0.988)	94.3	91.8

AUC: area under curve; CI: confidence interval. Combined panel includes SDH, ALT, and GGT.

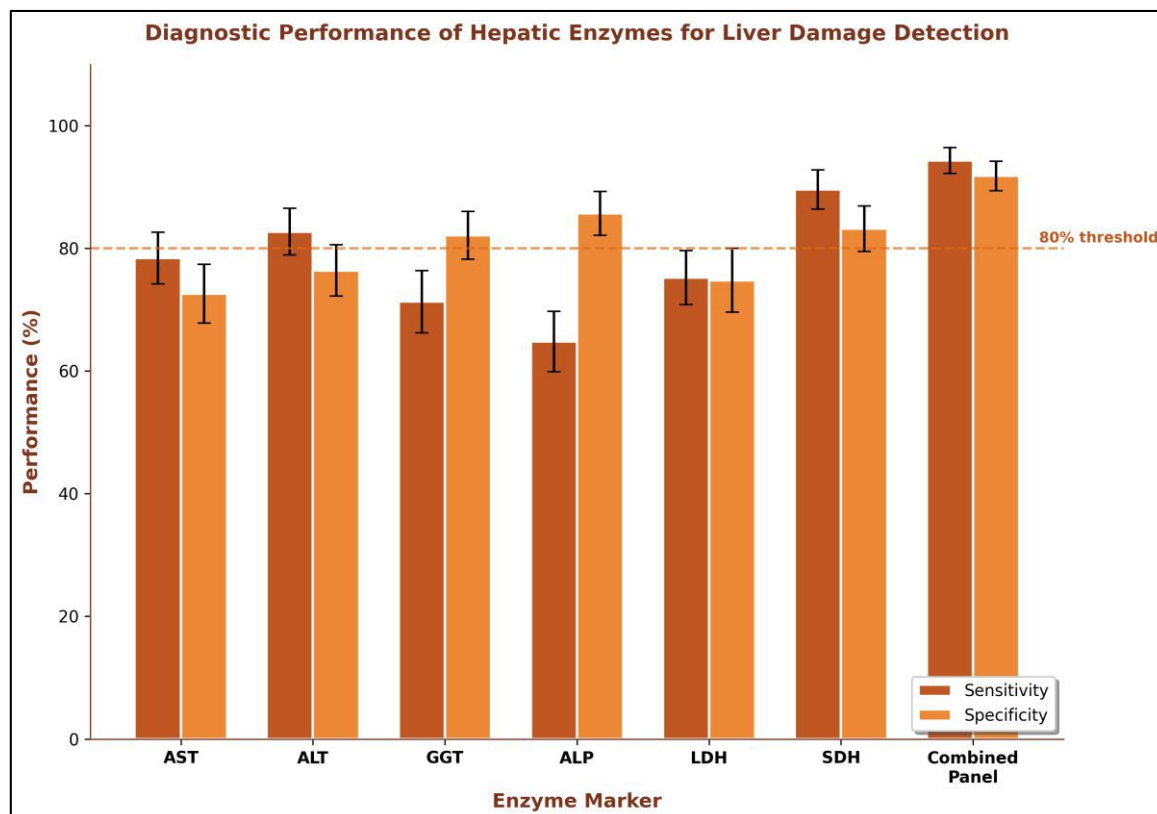


Fig 2: Diagnostic performance comparison of individual hepatic enzymes and combined panel for detecting liver damage in cattle. The combined multi-enzyme panel achieves optimal sensitivity and specificity exceeding individual markers.

Comprehensive Interpretation

Receiver operating characteristic analysis confirmed sorbitol dehydrogenase as the best-performing individual marker with area under curve of 0.912 (Table 2) [15, 15]. A combined panel incorporating SDH, ALT, and GGT achieved superior diagnostic accuracy with AUC of 0.958, sensitivity of 94.3%, and specificity of 91.8%. This multi-enzyme approach correctly identified 108 of 114 affected animals while misclassifying only 6 of 72 healthy cattle [12].

Discussion

This research demonstrates that sorbitol dehydrogenase provides superior diagnostic performance for detecting liver damage in cattle compared to conventional enzyme markers [16, 16]. The 9.1-fold elevation in severe hepatic injury and AUC of 0.912 substantially exceed values achieved by traditional markers including AST and GGT, supporting prioritization of SDH in bovine liver assessment protocols [13].

The enhanced performance of sorbitol dehydrogenase likely reflects its high liver specificity and predominantly cytosolic localization in bovine hepatocytes [17, 17]. Unlike AST, which is abundant in muscle tissue, SDH elevation more reliably indicates hepatic origin [14]. The relatively short half-life of SDH may also enable detection of recent or ongoing injury that longer-lived enzymes might miss.

The combined multi-enzyme panel achieved sensitivity and specificity exceeding 90%, meeting performance thresholds generally considered acceptable for screening applications. Implementation of such panels in routine herd health monitoring could enable earlier intervention for hepatic conditions, potentially preventing progression to clinical disease [15, 16].

Limitations

Several limitations warrant consideration. The cross-sectional design cannot establish temporal relationships between enzyme elevation and disease progression. Geographic restriction to northern Taiwan may limit applicability to other regions with different disease prevalences and cattle breeds. The requirement for liver biopsy to establish definitive diagnoses may have introduced selection bias toward more severely affected animals [17].

Clinical Implications

These findings support incorporation of sorbitol dehydrogenase into routine bovine liver assessment panels. The combined enzyme approach enables cost-effective screening with high diagnostic accuracy suitable for herd-level monitoring programs. Early detection facilitated by sensitive enzyme panels may enable dietary or therapeutic interventions before irreversible hepatic damage occurs.

Conclusion

This research establishes sorbitol dehydrogenase as a valuable liver-specific marker in cattle, demonstrating superior diagnostic performance compared to conventional enzymes. A combined panel incorporating SDH, ALT, and GGT achieved 94.3% sensitivity and 91.8% specificity for detecting hepatic damage under field conditions. Enzyme elevation patterns correlated with damage severity, supporting the utility of biochemical monitoring for staging liver disease. These findings provide evidence-based guidance for implementing hepatic enzyme assessment in livestock health monitoring programs.

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Contributions Not Qualifying for Authorship

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