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DISCLAMER
The views and findings published in Kruti/ कृति 2026 are those of the contributors.

FOREWORD

It gives me great pleasure to present the second issue of Volume 4 of *KRUTI – A Multidisciplinary Research Journal*. The journal is an important commitment of our institution's efforts to encourage research, promote academic exchange and provide a platform for sharing ideas and new findings.

I am particularly pleased to see that academic excellence is reflected in the various contributions from authors across Goa. The papers cover a range of disciplines, namely Konkani, English, Commerce, Food Technology, Microbiology and Physics, making it a poignant collection of scholarly contributions and references for scholars across different disciplines. The collection of papers in these issues reflects the richness of thought and academic engagement.

The editorial process for this issue has been guided by a commitment to maintaining academic standards. With an acceptance rate of approximately 54%, the manuscripts have undergone a careful review and selection process. I appreciate the authors for their interest in contributing to *KRUTI* and entrusting their work to be shared through this platform.

I congratulate all the authors whose papers have been included in these issues. My sincere appreciation also goes to the reviewers; members of the editorial team, the research and development cell and especially the editor, Dr. Manjunath Nayak, for their valuable time and efforts in bringing out this publication. Through *Kruti,* we hope to encourage more academicians, researchers and students to take up research activities and bring their work to a wider audience.

As an institution of higher learning, we recognise that a vibrant research culture has to be nurtured with opportunities that promote curiosity, creativity and deliberation. I hope KRUTI will continue to grow as a platform that brings together researchers from different disciplines and encourages meaningful academic engagement.

I envision KRUTI growing into a significant academic platform that connects disciplines, brings together diverse voices and inspires a new generation of researchers to think critically, question courageously and contribute meaningfully.

I wish the journal continued success and hope this issue will be a rewarding read for its contributors and readers alike.



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व्हडलें घर" ह्या कादंबरेंत चित्रायिल्लें पुर्तुगेज राजवटीचें काळें पर्व:इंक्विझिशन आनी ताचो परिणाम-एक नियाळ

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Abstract: गोंयच्या इतिहासांतलें सगळ्यांत भयानक आनी आंगार कांटो फुलोवपी पर्व म्हळ्यार इंक्विझिशन अशें म्हणल्यार अतिताय जावची ना.गोंयचेर शेंकड्यांनी वर्सां सावन वेग वेगळ्या राजवटिंनी राज्य चलयलें, कांय राजवटिंचो शेख रोखडोच आटापलो.तर कांय राजवटी दशकां हुंपून शेंकड्या परस चड काळ शेख गाजयत रावल्यो. तातुंतली एक म्हळ्यार पुर्तुगेज राजवट.पुर्तुगेज राजवटिच्या काळार, राज्य विस्तारीत करपांतूच न्हय तर मुखेल्यांनी धर्म पसरावपाची मोखूय तितल्याच तिव्रतायेन धरली.ही मोख, मुखार येवपी वर्सांनी इतली खर जायत गेली की ह्या काळोखी खंडाची आयज याद लेगीत काडली जाल्यार काळजाक पीळ येता. असल्याच काळाचें चित्रण करून वाचप्यांक गामागूम करून उडोवपी कादंबरी म्हळ्यार उदय भेंब्रे हांची "व्हडलें घर".पुस्तकांतली प्रस्तावना वाचून जाणवता की ही असली-तसली सादारण कादंबरी न्हय, तर गोंयांत पुर्तुगेज राजवटिच्या इतिहासांत जाल्लें सोशण आनी चेपण उजवाडाक हाडपी एक गडगंज दस्तावेज.

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साररूप उतरां- व्हडलें घर, इंक्विझिशन, धर्मांतर, धर्मकोल्ल,आव्तु द फॅ.

प्रस्तावना

गोंय हें भारत देशांतलें सगळ्यांत ल्हान राज्य. इतिहासांत, ह्या राज्याचें मोल पुर्तुगेजांक जाणवलें. गोंयच्या कांय वाठारांक तांणी आपल्या ताब्यांत घेतले आनी आपणाक जाय तशे ते ह्या वाठारांत रावपी लोकांक पिडापीड करूंक लागले. पुर्तुगेजान गोंयचेर राज्य चलयिल्ल्या काळाचो इतिहास कांय प्रमाणान कोंकणी साहित्यांत आयिल्लो आसा. म्हाबळेश्वर सैल हांची "युंग सांवार" ही कादंबरी, वी.जे.पी साल्दान्य हांची "सायबा बोगोस" ही कादंबरी आनी आतां "व्हडलें घर" ही कादांबरी त्या काळांत चलिल्ल्या आक्रमाणाचेर जावं जुलूमांचेर उजवाड घालता. "व्हडलें घर" ही कादंबरी जांणी वाचूंक ना, तांकां 'व्हडलें घर' म्हळ्यार कितें? वा हे कादंबरीचें नांव व्हडलें घर कित्याक? हो प्रश्न पडप स्वभावीक. पूण कादंबरी वाचल्या उपरांत कळ्ळें की 'व्हडलें घर' ही पुर्तुगेज सत्ते वेळावयली एक मुखेल इमारत जातूंत इंक्विझिशनाच्या कैद्यांक नाकाशेवट करप जाताले. आदली युसूफ अदिलशाची ती पालास. आफोंस दे आल्बुकेर्कान गोंय शार जिखतकूच तो थंय रावपाक लागलो. ताचे फाटल्यान जे गवर्नर वा वायसरॉय आयले ते लेगीत तेच पालासींत रावले.1554 वर्सा दाँ पेद्रु मास्कारेन्यस वायसरॉय आसलो तेन्ना ह्या पालासीचीं व्हडलीं पाशाणी सोपणां ताका चडपाक त्रास जावपाक लागले कारण ताची पिराय 70 वर्सांची आसली. बंदरा लागीं कोटांत आशिल्ले पालासींत कांय बदल करून तांणें ती सुदारली आनी तो थंय रावंक गेलो. तेन्ना सावन अदिलशान बांदिल्ली पालास रिती उरली. 1560 वर्सा इंक्विझिशन गोंयांत हाडलें तेन्ना ताका सुवात जाय पडली.ही वास्तू खूब व्हडली आशिल्ल्यान ती इंक्विझिशनाक दिली. इंक्विझिशनान ती अदिकूय वाडयली. पुर्तुगेज तिका सांता काझ म्हळ्यार पवित्र

घर(Holy Office) म्हणटाले. थळावे लोक मात भिरांतीन ते वास्तूक व्हडलें घर घर म्हणटाले.

उद्दिश्टां आनी पद्दत

उद्दिश्टां - हे कादंबरींत दिसपी अत्याचार, धर्मीक छळ, सांस्कृतीक विस्थापन, अस्मिताय ह्या सारक्या विशयांचो अभ्यास करप. तशेंच इतिहास आनी काल्पनेची जोड घेवन कादंबरी खऱ्या इतिहासीक घडणुकांक कादंबरेंत कशी रुपांतरीत करता ताचो थाव घेवप.

पद्दत - समिक्षेंत गुणात्मक, वर्णनात्मक आनी विश्लेशण पद्दत वापरल्या. मुखेल स्त्रोत म्हळ्यार 'व्हडलें घर' ही कादंबरी, जी पुर्तुगेज वसाहतवाद, गोंयचें इन्किझिशन, धर्मीक छळ, संस्कृतीक बदल आनी ताचे परिणाम हांचें चित्रण करपा खातीर बारीकसाणेन वाचल्या. ह्या अभ्यासांत पात्रां, घडणुको, संवाद,वर्णनां, प्रतिकां आनी परत परत येवपी विशयांचो बारीकसाणेन अभ्यास केला. खास करून वसाहतवादी धोरणांक आनी धर्मीक निर्बंधांक लागून प्रभावीत जाल्ल्या लोकांचे आनी समुदायांचे अणभव हे कादंबरींत कशे दाखयल्यात हाचेर भर दिला.

गोंयांत चलिल्ल्या इंक्विझिशनाची इतिहासीक फाटभूंय

"व्हडलें घर" ह्या कादंबरेच्या सुरवातेक लेखकान इंक्विझिशन गोंयांत कशें पावलें हाचो प्रवास मांडला. खंयचोय धर्म बळजबरी करून आपणावपाक लावप आनी लोक तो धर्म मनस्पुर्वेक आपणायना तेन्ना ताचो परिणाम म्हणून इंक्विझिशना सारकीं यंत्रणा जल्माक आयलीं म्हणचे परस अधिकाऱ्यांक ती जल्माक घालचीं पडलीं म्हणल्यार चड समा जातलें. 15व्या शेंकड्यांत स्पेन राज्यांत इंक्विझिशनान अच्छेव मांडलो.क्रिस्तांव जाल्ले लोक क्रिस्तांव धर्म सारके पाळिनाशिल्ले. आदल्या धर्माच्यो रिती ,परंपरा, चाली पाळटाले आनी 'बरे क्रिस्तांव' ते जावंक नाशिल्ले. हाचेर उपाय म्हणून तोमाज दे तोर्केमाद ह्या पाद्रीन 1481 वर्सा इन्क्विझिशन स्थापन करून ताच्या न्याय मंडळा वरवीं गुन्यांवकारांक ख्यास्त दिवपाची येवजण मांडली. इंक्विझिशन ही खाशेली अशी यंत्रणा.धोरण राजा थारायतालो. ते यंत्रणेचो मुखेल वांटो म्हणल्यार न्याय मंडळ दोन वा तीन इंक्विझिटर हे ताचे वांगडी. जे बरे क्रिस्तांव जावंक पावले नात असल्या गुन्यांवकारांच्यो केशी न्याय मंडळ चलयतालें आनी तांच्या गुन्यावांक फावता तशी ख्यास्त दिताले.किरकोळ गुन्यांवाक किरकोळ ख्यास्त आनी खर गुन्यांवाक लासून मारपाची ख्यास्त.ह्या ख्यास्तींची मोख म्हळ्यार हेरांच्या मनांत भंय निर्माण करप.सुरवातेक फक्त धर्मा आड चलिल्ल्यांक इंक्विझिशन ताब्यांत घेतालें, मुखार जांचे कडेन आस्पत आसा असल्या लोकांक फटिंच्या आरोपानीं इंक्विझिशन फसोवंक लागलें.करूंक नाशिल्ले गुन्यांव फटिचे गवाय हाडून, गुन्यांवकार म्हणून धरून व्हेला ताका मान्य करूंक फोर्सार काडटाले आनी निमाणेकडेन दोशी ठरूं वा ना तांकां इंक्विझिशनाचे ख्यास्तीन लासून तांची आस्पत आपल्या ताब्यांत घेताले. हीं भाटा-बेसां मुखार लोकांक धर्मांतर करूंक लांच दिवंक वापरताले.1483 वर्सा पाद्री तोर्केमाद हाका पयलो इन्क्विझिटर नेमलो.पुर्तुगालांत इंक्विझिशन 1541 वर्सा स्थापन जालें आनी कांय वर्सांनी, म्हणल्यार 1560 वर्सा तें गोंयांत स्थापन जालें. गोंयांत पुर्तुगेज 1510 वर्सा पावले. 1540 वर्सा तांणी क्रिस्तांव धर्माचो प्रसार सुरू केलो. 1543 वर्सा व्हिकार जनरल मिगेल व्हाज हाणें पुर्तुगालाच्या राजाकडेन गोंयांत इंक्विझिशन स्थापन करपाची मागणी केली.पूण हें मागणें हेर पाद्रींक पटलें ना देखून तें तेन्ना मान्य करिनासतना मुखार दुखल्लें. मजगतीं, 16 मे 1545 दिसा सेंट फ्रान्सीस झेवियर हांणी राजा दॉ ज्युआंव हाका पत्र बरोवन गोंयांत इंक्विझिशन स्थापन करचें म्हणून मागलें. राजान ताकतिकेन निर्णय घेतलो ना, पूण 1560 वर्सा गोंयांत इंक्विझिशन आयलें. 1774 वर्सा मार्केज दे पोम्बाल पुर्तुगालाचो मुखेल प्रधान जालो.ताणें इंक्विझिशन बंद केलें.पूण 1778 वर्सा ताचें पद गेलें आनी इंक्विझिशन

परत जितें जालें.अखेरेक 1812 वर्सा तें अधिकृत रितीन बंद जालें.

गोंयच्या समाजाच्या मनस्थितीचेर तसोच गोंयच्या संस्कृतायेचेर इंक्विझिशनाचो जाल्लो परिणाम

पुर्तुगेज गोंयांत येवन क्रिस्तांव धर्म शिपडावपाचो वावर करूंक लागले, शिपडावप म्हणचे परस बळजबरेन तो लोकांक स्विकार करपाक लावंक लागले अशें ही कादंबरी वाचतकच नक्कीच थावें जाता, कादंबरेंत चित्रायिल्ल्या कांय प्रसंगांनी हाची खात्री जाता.देखीक- "रवळू नायक 21 वर्सांचे पिरायेचो.10 वर्सांचे चलये कडेन लग्न जालो.हे चलयेक बापूय ना हे खातीर ती अनाथ जाल्ली आसा असो अर्थ लावन फिर्गीं पाद्रींनी ते व्हंकलेक बळजबरेन घरांतल्यान व्हेली आनी बाउतीज्म दिवन क्रिस्तांव केली.रवळू नायकान वाद घालो...तांणी एकूच सांगलें,तूं क्रिस्तांव जा, तुका बायल मेळटली.रवळू नायकान बाउतीज्म घेतलो." (भेंब्रे 2021,प.139) तर कांय लोक आपल्या लाचारेक लागून आनी पुर्तुगेज, स्वता आपूण जावन क्रिस्तांव जावंक सोदतल्या लोकांक भाटांची मालकी, दुडू दिता म्हणून आयकिल्ल्यान त्या धर्मांत रीग घेवपाक लागले."बाटल्यार जायतें मेळटा अशें ताणें आयकलें.सारकी खबर काडटकच ताका कळ्ळें बाटल्यार सरकाराक देणें आसा तें माफ जाता.पाखले न्हेसतात तसलें न्हेसण मेळटा.जमनीचो कुडको मेळटा.पैशे मेळटात.सरकारी चाकरी मेळटा." (भेंब्रे 2021,प.138)

जे कट्टर हिंदू आशिल्ले पूण जांचे कडेन दौलतिची राश आशिल्ली असल्यांक तांच्या शेतां-भाटांचेर ताबो करतले आनी तांकां गांवपणांत मेळपी सगळे हक्क काडून उडोवन ते हक्क फक्त क्रिस्तांव धर्माच्या लोकांक मेळटले अशें भेडकावन तांकां धर्म बदलूंक फोर्सार काडटाले. असल्या वेळार आपल्या पुर्वजांच्या दायजाची राखण करूंक खूब हिंदू लोकांनी धर्मांतर जावन क्रिस्तांव धर्म आपणायलो. "घर, जमीन हांचें धनीपण उरचें आनी गांव सोडून वच्चो प्रसंग येवचो न्हय हे खातीर आपणें क्रिस्तांव धर्म आपणायलो." (भेंब्रे 2021,प.135) "गांवकारींत क्रिस्तांव गांवकार आसत जाल्यार ते हाजीर आसल्यारूच गांवपण जातलें..थारावणी बरोवन निशाणी घालतना आदीं क्रिस्तांव गांवकारांनी घालपाची आनी मागीर कोंकणे गांवकार आसात जाल्यार तांणी.." (भेंब्रे 2021,प.150)

कांय लोकांनी क्रिस्तांव धर्म आपखोश्येन जावं वा बळजबरेन जावं, तो स्विकारून घेतलो आनी मना काळजान त्या धर्माच्यो चाली रिती बाउतीज्म घेतिल्ल्या दिसा सावन ते पाळूंक लागले. "धर्म बदलपाची म्हाका केन्ना इत्सा जाली ना...म्हाका गांवांत रावपाक जाय आशिल्लें.धनीपण गांवकारपणाचे हक्क राखून दवरपाचे आशिल्ले...ते खातीर दुसरी वाट ना म्हणून हांव क्रिस्तांव जालों.बाउतीज्म घेतकूच हांवें पुराय निश्ठा क्रिस्तांव धर्माक दिली...धर्मीक कर्तव्याक खंयच चुकलों ना." (भेंब्रे 2021,प.154)

मात कांय जाणां भायल्यान क्रिस्तांव धर्माचो स्विकार करतालीं पूण भितरल्यान त्योच आदल्या धर्माच्यो चाली-रिती लिपचोऱ्यांनी पाळटालीं. "हे नवे क्रिस्तांव वायलेचाराक आपूण क्रिस्तांव अशे दाखयताले,इगर्जांनी मिसाक वताले,पूण भितल्ल्यान ज्यू धर्माच्यो रिती पाळटाले". (भेंब्रे 2021,प.44) "रातची न्हिदूंक येतकूच ती कुडीच्या दाराक खिळी घालताली.कापड न्हेसून,मंगळसूत्र घालून,पेट उगडून देवतेची मूर्त काडटाली. पेट धांपून ती पेटेर दवरून तिका फुलां घालताली." (भेंब्रे 2021,प.67)

कांय लोक धर्मांतराक तोंड करपाचें ना म्हणून गोंयांत जंय आदिलशाचो शेख चलतालो तसल्या वाठारांनी वचून स्थायीत जाले. वतना आपले वांगडा ते आपल्या देव-देवतांक आपल्या सांगाता घेवन गेल्ल्याची जाण आनी गांव सोडपाची तशेंच देव-देवतांक सुरक्षितपणान दुसऱ्या जाग्यार व्हरपाची प्रक्रिया बारीकसाणेन कादंबरेंत मेळटा. "कुठ्ठाळच्या गांवकारांनी खंय फाटले पंद्रशेंत मंगेशाचें लिंग थंयचें हालोवन अंत्रूजेंत

व्हेलां.केळशीच्या गांवकारांनीय शांतादुर्गेची मूर्त अंत्रूजेंत व्हेल्या." (भेंब्रे 2021,प.108) "अंत्रुजेंतूच वचपाक जाय अशें ना.न्हयेचे पलतडीं आदिलशाचें राज्य...देव-देवतांचेर फिग्र्यांचो हात पडचे आदींच तांकां घेवन आमी शिरोड्या वच्चें अशें म्हाका दिसता." (भेंब्रे 2021,प.108)

तर खुबशे कुटूंब गोंयच्या भायर, हेर राज्यांनी आपलो धर्म राखूंक आनी राबितो,आलाशिरो तेच भशेन नोकरेची वा वेवसाय करपाची संद आशिल्ल्या वाठारांनी पळून वा लिपचोऱ्यांनी गेल्ल्याचीय गवायकी ही कादंबरी दिता.हे असले कुटूंबांची संख्या एक दोन नासून पुराय गांवचे गांव रातचे वेळार रिते जावंक लागले अशेंय आमकां वाचूंक मेळटा."काळोख जावंक लागलो तशीं वेगवेगळ्या गांवांतलीं कुटूंबां मडगांवांत साळ न्हयेचे देगेर आशिल्ल्या धक्या शेजरा बांदार येवन रावलीं....सगळीं मेळून 103 कुटूंबां आशिल्लीं." (भेंब्रे 2021,प.131-132) "मंगळूरच्या धक्या कडेन व्हडीं एक दीस रावलीं.ही व्यापाराची पेठ...दिसवड्याचो वावर करपाक संद बरी आसा.43 कुटूंबां मंगळूरांत रावचे खातीर देंवलीं." (भेंब्रे 2021,प.132) "व्हडीं फुडें सरलीं, जेवणा खातीर तीं कालेकूत बंदरांत रावलीं. हे बाजारपेठींत भोव बऱ्यो संदी आसात अशें कांय व्यांपाऱ्यांक दिसलें.असल्या व्यापाऱ्यांचीं 21 कुटूंबां थंय देंवलीं." (भेंब्रे 2021,प.132-133) "उरिल्ल्या कुटूंबांक घेवन व्हडीं फुडें गेलीं. कोची बंदरा लागीं थारलीं.कांय मुखेली राजाच्या कारभाऱ्यांक मेळ्ळे. राजाक पुराय निश्टा ओंपतले अशें उतर दिलें...राजान त्या कुटूंबांक आलाशिरो दिलो. तीं थंय रावलीं" (भेंब्रे 2021,प.133)

व्हडलें घर ह्या कादंबरेंत आयिल्लो काळ

गोंयांत इंक्विझिशन 1560 ते 1812 वर्सा चल्लें पूण ह्या कादंबरेंत लेखकान फक्त 1566 ते 1585 ह्या वर्सां मदलो काळ चित्रायला. त्या काळार पुर्तुगेजांच्या ताब्यांत फक्त तीन (आयचे चार) म्हाल आसले-मुरगांव,तिसवाडी,साश्ट आनी बार्देस.16व्या शेंकड्यांतलें गोंय आयच्या गोंयचे परस खूब वेगळें आसलें.इंक्विझिशन स्थापन जाले नंतर गोंयचे चार म्हाल जे पुर्तुगेजांच्या ताब्यांत आसलें ते तीन पंथां मदीं वांटून गेले-फ्रांसिस्कान,जेजुईत आनी डॉमिनिकी.कथानक फक्त वयर दिल्ल्या 20 वर्सां मदीं घडिल्ल्या गजालींचो आस्पाव करता आनी त्या काळांत चलिल्ल्या अच्छेवाक धरून मर्यादीत आसा.

हे कादंबरेंत व्हडलें घर, ताका तेंकून आशिल्ली बंदखण,ते बंदखणींतल्यो कुडी,कैद्यांक दिताले तें जेवण,बंदखणींतल्यो रिती,न्याय मंडळांचें साल,इंक्विझिटरां मुखार जाताली ती तपासणी,आव्तु द फॅ,गोंयांत त्या काळार जाल्ले बंड, त्या काळांतलो व्यापार-धंदो,कांय मनशांच्यो वा व्यक्तिंच्यो जिवन पध्दती,स्थलांतरां हांचें विशींचीं वर्णनां आयल्यांत.

इंक्विझिशन ह्या कादंबरीचो मुखेल विशय आसून लेखकान केल्ली थळ वर्णनां, रितींचें चित्रण, हिंदू गोंयकारांचेर जाल्लें आक्रमण परिपूर्ण रितीन चित्रायला. वाचून वाचतल्याच्या काळजाक चिरून उडोवपी सत्य घडणुकांची मांडणी कल्पक्तायेचो थोडो भोव आदार घेवन अशी कादंबरी निर्माण करपाक लेखकान इतिहासांत घडिल्ल्या गजालींचे खूब कितें वाचलां, आयकून घेतलां म्हणून वाचप्याक खिणा खिणाक होलमत रावता.

वयर उल्लेखिल्ल्या काळांत भाटकार-मुंडकार प्रता चलताली हें जाणवता. "मतेस थंय लागींच खोंपींत रावतालो.ज्याकीन ताची बायल.दोगांय भाटांतलीं कामां करी."26

घोडे, व्हडीं, तार, माच्यूल वापरून प्रवास करप जातालें. "घोडो ताणें त्या सोल्दादाचे सुवादीन केलो आनी तो व्हड्यांत वचून बसलो." (भेंब्रे 2021,प.27). "मानायांक सांगून माच्यूल भायर हाडून घेतलें." (भेंब्रे 2021,प.55) "तार चोडणाचे दिशेन वचूंक लागली".102 "ते चान्याचे राती व्हडें शिरोडेंच्या धक्याचे दिशेन वतना सरभोंवतणीं सगळें शांत" 116. व्यापारा खातीर तारवावळीचो वापर जातालो. हातूंत ल्हान-व्हड अशीं वीस मेरेन तारवां आसतालीं जीं

घोडे,गुलाम,येवरोपांतलीं वस्त्रां आनी हेर जायतो म्हाल घेवन येतालीं. "ही तारवावळ भोव करून एप्रील म्हयन्यांत पुर्तुगालच्यान भायर सरता." (भेंब्रे 2021,प.91) पालखीचो वापरूय त्या काळांत जातालो. फिदाल्गांच्यो बायलो इगर्जेंत वचपा खातीर पालखीचो वापर करताले. "पालखी सकयल देंवयतकच दॉना आंजेला देंवता". (भेंब्रे 2021,प.94)

वेगवेगळे वेवसाय जावं धंदे चलोवपी व्यक्तिंचो जावं पुर्तुगेज हुद्दे आशिल्ले अधिकारी, पुर्तुगेजां खातीर काम करपी,तशेंच गोंयांत आशिल्ल्या कांय जातींचो कादंबरेंत उल्लेख आयला-भाटकार, मुंडकार, गुरव,जोगी,बामण, भट व्हलेकार,व्हडेकार, झाडपाल्याचो

वैज,मानाय,रेंदेर,शेटी,व्यापारीसोल्दाद,फामि लियार,शिपाय,कापितांव, पुर्तुगेज भाशेंतले शेर्मांव कोंकणी भाशेंत सांगपी दुभाशी(गोंयकार पाद्री वा सादारण पुर्तुगेज भास शिकिल्ले गोंयकार),आफ्रिकी वावराडी,आल्काईद,इंक्विझिटर,

सेक्रेटरी,फिर्गीं पाद्री,वासरॉय,गोवेर्नादोर आदी

थळचित्रणां जी पुर्तुगेज काळांतलीं चित्रायल्यांत तीं घडयेक आयज गोंयांत नात सोडून एख हात कात्रो खांबो. पूण तरी आसतना वेगवेगळे गोंयचे गांव त्या गांवांत स्थायीत आशिल्लीं देवळां, इंक्विझिशनाची पालास म्हळ्यार व्हडलें घर आनी लागीचें वाठार कादंबरींत वाचपाक मेळटात. व्हडलें घराचें चित्रण इतले बारीकसाणेन आसा की वाचतना दिसता की आमी स्वता तें घर आमच्या दोळ्या मुखार तश्या तशें रंगोवपाक शकतात."रोखडेंच वायसरॉयचें आर्क लागलें.पुर्तुगेज ताका 'तेरैरू दे साबाय्यु' म्हणटाले..सगळ्यो वण्टी चार हात रुंदायेच्यो." (भेंब्रे 2021,प.21-22) "कायतानाचे कुडीक दोट्टी दार, एक भितल्ल्यान उगडटा....पूण जळार खूब आशिल्ल्यान तें तांकां जाय पडटालें"31 तशेंच "कायतान एक ल्हानशे कुडींतल्यान दुसऱ्या एका दारांत पावलो....तर दुसरे वटेन दुभाशी बशिल्लो"40 "ह्या शारांत दोन हातकातरे खांबे आसात" भेंब्रे 2021,प.90) आनीक एक जितें जिवें थळवर्णन जें यशस्वी रितीन जालां तें म्हळ्यार "व्हडल्या घराचे पुर्वेक सुमार 500 मिटरांच्या अंतराचेर मांडवी न्हंयचे देगे वयलें हें मळ..." (भेंब्रे 2021,प.206-209)

त्या काळांत पुर्तुगेजांनी कांय नेम काडिल्ले जे पाळप सक्तीचे आसले.हे नेम मोडप्यांक फक्त एकूच ख्यास्त, ती म्हळ्यार इंक्विझिशन. 1556 वर्सा असो नेम जाहीर केलो की 14 वर्सां सकयल एकाद्या हिंदू चलयाचो वा चलयेचो बापूय संवसाराक अंतरलो त्या भुरग्यांक बाउतिज्म दिवन क्रिस्तांव धर्म दिवप जातालें. भुरग्यां वांगडा हेर फामिलीचें दायजूय पर्तुगेज आपल्या ताब्यांत घेताले. उपरांत 1559 वर्सा ह्या नेमाची दुरुस्ती केली.पालक तशेंच आजो-आजी नासत जाल्यारच असल्या भुरग्यांक क्रिस्तांव धर्मांत रिगोवपाचें काम करप ना तर तो अनाथ न्हय. जो कोण अनाथ भुरग्यांक लिपोवन दवरपाचें वा धर्म राखून दवरपा खातीर हेर वाठारांनी ताका वा तिका फरार करपाचें धाडस करता तो इंक्विझिशनाचो बळी थरतालो. असल्याच एका फटींग आरोपांत कादंबरींतलो कायतान सांपडिल्लो दिसता. (भेंब्रे 2021,प.42)

लिपचोऱ्यांनी हिंदू धर्माच्यो चाली रिती पाळ्ळ्यारूय इंक्विझिशनाचो कैदी म्हणून तुका ताब्यांत घेताले.कोंकणी भास उलोवंक जायनासली. मुर्तिंची पुजा करूंक जायनासली. लोकवाद्यां वाजोवंक फावनासलें. पुडवें-धोतर न्हेसपाचेर बंदी आसली.बळजबरेन जाल्ल्या नव क्रिस्तावांक गोंयच्यान भायर पळून वचपाक मदत करपांत हात आसल्यार लेगीत इंक्विझिशनाची खर ख्यास्त भोगची पडटाली.वयर दिल्ल्या नेमा भायर आनिकूय कांय नेम ह्या कादंबरेंत आयल्यात जे पुर्तुगेजांनी कडक केल्ले. देखीक हिंदूंची लग्नां तांच्या गांवांनी करचीं न्हय....व्हडें न्हंयेंत मदीं व्हरून थंय लग्न करचें" 47 हिंदू गांवकाराचे हक्क गांवपाणांत उणे केल्ले. भेंब्रे 2021,प.149-150) "आंगणांत वा पोरसांत तुळशीचो रोंपो आसूंक जायना....काजाराच्या सुवाळ्यांनी पानांचे विडे वांटूंक जायना." (भेंब्रे 2021,प.183-184)

"गांवांत रावतले जाल्यार हिंदूनी क्रिस्तांव जावचें.... ना जाल्यार तांची आस्पत जप्त जातली" (भेंब्रे 2021,प.150)

क्रिस्तांव धर्म घेवपाक सोदतल्या हिंदू लोकांनी आपल्यो आदल्यो चाली रिती सोडून दिवप आसताल्यो आनी क्रिस्तांव धर्म स्विकरूंक मना-काळजांतल्यान तयारी करपाक तांकां दोन म्हयन्या खातीर पाद्री क्रिस्ती शिकवण दिताले. जाका कातेकुमेन वा दोतोन्न म्हणटात. (भेंब्रे 2021,प.173,180-182)

त्या काळांत व्यापारा बाबतींत गोंय एक नामनेचें बंदर आशिल्लें. पुर्तुगालच्यान व्यापारान भरून तारवावळी गोंयांत येताल्यो आनी वतना गोंयांत उत्तपन्न केल्ले मसाले, आनी हेर जिनस घेवन वताले. (भेंब्रे 2021,प.91)

पुर्तुगेज राजवटींत बायलेचें समाजीक स्थान - फिदाल्गांच्या बायलांक फावो तो मान मेळटालो पूण तांकां सादारण बायलां भशेन मेकळीक नाशिल्ली. तांकां आयतार हो फेस्ताचो दीस कसो, कारण फक्त त्याच दिसाक मिसाच्या निमतान तांकां घरांतल्यान भायर सरूंक मेळटालें. वतनाय मेकळेपणान वा एकट्यान तिच्यान वचूंक जायनासलें. चाकर वा घरांतले गुलाम तिका पालखेन हाड व्हर करताले. कादंबरेंत "दॉना आंजेला" ही एका फिदाल्गाची बायल दुमींग नांवाच्या तरणाट्याक कशे रितीन आपल्या घरांत येवपाक आमंत्रण दिवन आपल्या कुडीची आस भागयता हें दिसता. (भेंब्रे 2021,प.93-96)

"मार्गारीद" हिच्या घोवाक काजार जावन तीन वर्सां जातात थंयच आसलीं पूण आर जाल्ली, तिच्या सोबितायेन मात एका इंक्विझिटराक पिशें लायिल्लें.गुन्यांव नासतना मार्गारीदाक ताणें कैदी म्हणून व्हडल्या घराच्या कुडींत बंद करून दवरिल्लें आनी आत्र्या-पर्यान तिच्या कुडिचो भोग मात घेवन ह्या इंक्विझिटराक पुरो जायनासलें. निमाणेकडेन सोसूंक जायना जावन आपली हातीची शीर कातरून ती बंदखणींतच जीव दिता. (भेंब्रे 2021,प.44-46 आनी 69)

गुलाम चलयो जांकां तारवांनी हाडप जातालें तांची पावणी जाताली.जाणट्या बायलांक चलयांक तपासून पळय म्हणून सांगून उपरांत त्या चलयांक पावणी जिखून गुलाम म्हणून विकती घेवपाची चाल आसली. (भेंब्रे 2021,प.92-93)

कथानकाचेर उजवाड

कायतान हो राय गांवचो एक नव क्रिस्तांव आनी गांवकार.ताचें आदलें नांव वासू पै.कादंबरिची सुरवात कायतानाच्या अटकान जाता.फामिलियर ताका व्हडल्या घरा व्हरपाक येता पूण कित्याक हाची म्हायती कायतानाक वा हेर कोणाकूय नासता. कायतानाची बायल पियेदाद (आदलें नांव गोमती) मात एकसूरी पडटा. ताचो गांवचो इश्ट गोपू शेटीक ही खबर कळटा तेन्ना तो पियेदादीच्या भाव-दियोगाक रकाद धाडटा. दियोग आपले भयणीक आपल्या वांगडा आपल्या घरा घेवन येता. पियेदादिची भलायकी बरी उरना हाची ताका आनी ताच्या घराब्याक जाणीव आसता.वासूल्या भावा आनी व्हनी तांच्या दोगूय भुरग्यांक आपलो धर्म राखून दवरचे खातीर गोंय सोडून वतात तेन्ना आपले वांगडा घेवन वतात पूण तीं खंय गेल्यांत,हें कादंबरी सोंपसर एक कुवाडेंच उरता. तेन्नासावन तिका धपको लागता.कांय लोकांकडल्यान तो वासूक कित्याक व्हडल्या घरा व्हेला काय म्हणपाची खबर काडटकच ताका कळटा की कोणाक कित्याक व्हेला हें थंय पावले शिवाय कळपाक मार्ग ना मात, व्हडल्या घरांत एक फावटी मनीस भितर गेलो म्हणटकच तो एक तर थंय भितरच मरता वा ताका इंक्विझिशनाची ख्यास्त म्हळ्यार उज्यान लासपाची ख्यास्त फावो जाता. व्हडल्या घरांत भितर आसतना कायतानाक आपल्या फाटल्या कांय वर्सांच्यो यादी येतात. कशे रितीन ताचो बापूय-आवय आनी ल्हान भाव धर्म राखपा खातीर गोंयच्याच एका दुसऱ्या वाठारांत वचपाचो निर्णय घेतात आनी उपरांत तो, ताचे हेर भाव कशे एक एक करून फापसतात ताची एक एक करून ताका याद जाता. मदीं मदीं दियोगाच्या घरांत रावपी

पियेदाद सिंतिदान नासता देखून दोन फावटी तरी घरांतल्यान एकटेंच भायर सरून वता आनी मागीर खूब वेळ ताची सोद घेतकच मेळटा.एक दीस उटंगराचो पावस पडटा आनी पुराय गांवांत उदकाचे लोट व्हांवतात, पियेदाद घरांतल्याचे दोळे आड करून नाच जाता. तिका सोदूंक गेल्यार ती खंयच मेळना, दियोग आनी ताचो पूत लुईस तिका सोदपाचो खूब प्रयत्न करतात.दोन दिसा उपरांत उदकाचो नेट कमी जाल्ल्यान भरिल्लें उदक देंवता तेन्ना,कोणाक तरी पयस एक कपडो दिसता, दियोगाक कोण तरी रकाद पावयता की ताणें चवकशी करूंक येवची.पूण जेन्ना तो आनी ताची बायल थंय पावता तेन्ना उदकांत दिसा वयर ती कूड उरिल्ल्यान ती कूड वळखूंक लेगीत मार्ग नासता.पूण तिच्या गळ्यांतल्या कोंताक लागून दियोगाची बायल तेरेज तिका वळखता. तिचो इंतेर दियोगाच्या घराकडेनूच करतात.मदीं-मदीं कायतानाक इंक्विझिटर फटिच्या आरोपान फसयतात म्हणून कायतानाकूय बेस बरें खबर आसता.परत परत इंक्विझिटरा मुखार व्हरून ताका आपणें करूंक ना तो गुन्यांव मान्य कर म्हणून ताका फोर्सार काडटात.अशे रितीन दोन वर्सां कायतान कैदी जावन उरता.दियोगाच्या पुताक कोण तरी 'आव्तु द फॅ' जावपाचें आसा हाचे विशीं कळयता. तो आपल्या इश्ट मार्सेलीनाक आपणाक तें पळोवपाक जाय म्हणून हट्ट धरता. ताचो इश्ट ताका थंय घेवन वता.कैद्यांक उज्यान लासचे पयलीं तांचें व्हडलें पुरसांव काडटात, इगर्जेंत व्हरतात आनी उपरांत एका लागशिल्ल्या मळार व्हरून लासतात. हे कैद्यांनी एक खाशेलो भेस न्हेसून ह्या पुरसावांत वांटेकार जावपाचें आसता.तेन्नाच लुईसाक कितें तरी जावन तो लकता आनी सिंतिदा भायरसो पडटा देखून ताका मार्सेलीन परत घरा हाडटा. दोतोरान दिल्ल्या वखदाक लागून तो फुडल्या दिसा मार्सेलीनाक उठून परत या म्हणून सांगता. पूण कायतान आनी हेर कैद्यांसयत जें कितें जावपाचें आसलें तें आदल्या दिसा जाल्ल्याची म्हायती मार्सेलीन ताका दिता.

आव्तु द फॅ

दोन वर्सां, इंक्विझिटर आनी कैद्या मदलो प्रस्न-जापेचो काळ जाल्या नंतर **आव्तु द फॅ** हो ख्यास्तीचो दीस निमाणेकडेन कादंबरेंत इतल्या क्रूरतायेन चित्रायला की एक फावट ही कादंबरी वाचल्या उपरांत सदांकाल तो वाचप्याच्या मनांत कोरांतून उरपा सारको. कैद्यांक दिल्लें न्हेसवण कशे रितीन तांणी पातक आदारिल्ल्यान ते सैतानाच्या खोंडांत लासून मरतले अशे रितीचें प्रतिकात्मक दृश्यां रंगयिल्लें आसता. तांकां पुरसांवांत रस्त्यावेल्यान व्हरप म्हळ्यार तांकां एके तरेन लज भोगची म्हणून केल्ली पुर्तुगेजाची मांडणी ना तर मरतल्याक लोकांमदीं उक्ताडार पुरसांव काडून सबेमाजार तांच्यो केशी कित्याक वाचप आनी लजेक घालप? हें "भावार्थाचें कर्तुब" नासून पुर्तुगेजांनी आपल्या मनरिजवणे खातीर आनी हेर समेस्तांच्या मनांत भंय रिगोवपा खातीर केल्लें फटिंगपणाचें नाटक.

निश्कर्श

ह्या कादंबरेंत आयिल्लो काळ, थळवर्णनां, घडणुको वाचप्या मुखार इतिहासाचें जितें-जिवें चित्र उबें करता.धर्मांतर ह्या विशयाक धरून बरयिल्ली कादंबरी त्या काळांतल्या खुबश्या समाजीक प्रश्नांक हात घालपाचो यत्न करता.वसाहतवादी सत्ता फकत राजकारणांतल्यान न्हय, तर धर्म, समाज आनी संस्कृतायेचेर नियंत्रण दवरूनय काम करता, अशें ह्या कादंबरेंत दिसून येता. आनीक एक म्हत्वाचो मुद्दो म्हळ्यार गोंयचो समाज आपली वळख आनी अस्मिताय शेणिल्ल्याची भावना आनी संघर्श कादंबरेंत उक्तायिल्लो मेळटा. पारंपारीक चालीरिती सोडपाक लावन, नव्या धर्मीक आनी संस्कृतीक चालीरिती आपणावपाक प्रवृत्त जाल्ल्या समाजांत तणाव निर्माण जाल्लो दिश्टी पडटा. तेचपरी इतिहासाचो सगळो दबाव आसून लेगीत लोक कशे प्रतिकार करतात आनी आपली वळख आनी सांस्कृतीक याद दवरपा खातीर, दुसऱ्या सुवातांनी स्थलांतर जावन लेगीत कशी जिवी

दवरतात हेंय कादंबरेंत दाखयलां. शंब्दभंडाराच्या नदरेंतल्यान विचार केल्यार कादंबरेंत खुबशीं पुर्तुगेज उतरां जांचो इतिहासांत वापर जातालो हांचो उल्लेख केल्लो मेळटा. तेश भशेन काय स्थळां,स्मारकां,देवळां जी घडयेक आयज त्या वाठारांत नासत पूण इतिहासाचीं मूळां थंय रिगिल्लीं आशिल्ल्यान तांचेरूय फावो तो उजवाड पडिल्लो दिसता.इंक्विझिशनाचो काळ, हो फक्त कांयच वर्सांचो नासून तो शेंकड्या परस चड तिगून उरिल्लो टप्पो आसा. पूण ह्या काळाचो आवांठ एक कांदबरेपुर्तोच मर्यादीत करपाक लेखक येशस्वी जाला. कादंबरी फक्त मुखेल कथानका भोंवतणीच न्हय तर ती वंय मोडून तांणी तातूंत हेर घडणुको, जावं हेर पात्रांची चाल चलणूक गुंथून इतिहाचेर अदीक भर पडचेपासत सुरबूस रितीन ती वाचप्यां मुखार दवरल्या.देखीक आसोळणें कुंकळी वेलीं बंड, कांय फिदाल्गांची जिवणपद्दत, त्या काळार चलपी व्यापार,पाद्रींचे मदीं घडिल्ली भासाभास आदीं. लेखकान इतिहासाचो बारिकसाणेन अभ्यास केला आनी इतिहासाचे फास्केंत आपलीं पात्रां मुदयेर तीक कशीं बसयल्यांत आनी आपले कल्पनेचो वाव घेवन कादंबरी फळयल्या अशें म्हणूंक कांयच हरकत ना.केन्नाच आयकूंक नाशिल्लें वा वाचूंक नाशिल्लें कितेंय नवीन वाचतकच कितें तरी नवें ज्ञान मेळिल्ल्याची, आनी वाचप्यांक संतुश्ट करपा सारकी इतिहासाची आवड आशिल्ल्या दर एका गोंयकारान वाचून कडपा सारकी ही कादंबरी आसा.

Conflict of Interest

हितसंबंधांचो संघर्श ना.

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Trends in Organic Export Performance and Value Creation

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Abstract: *Organic farming is increasingly recognised as a cornerstone of sustainable agriculture, offering ecological benefits, market differentiation, and export potential. This study analyses growth and instability in Goa's organic sector over the past decade, following the introduction of the Paramparagat Krishi Vikas Yojana in 2015 by the Government of India under the Ministry of Agriculture and Farmers Welfare, as a sub-component of the National Mission for Sustainable Agriculture. Using the Compound Annual Growth Rate (CAGR) and the Cuddy–Della Valle Instability Index (CDVI), the results reveal a steady expansion of the area under organic cultivation, accompanied by low instability. In contrast, export volumes and values have declined, exhibiting high and medium instability, respectively. These findings highlight vulnerabilities arising from market fluctuations, supply chain inefficiencies, and weak value-chain integration. Policy interventions to strengthen market linkages, improve infrastructure, and diversify exports are crucial for enhancing resilience and sustaining growth in Goa's organic agricultural sector.*

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INTRODUCTION

Over the past decade, India's organic farming sector has undergone a remarkable transformation, positioning the country as a global leader in sustainable agriculture (Willer et al., 2026). This transition has been driven by a convergence of traditional ecological knowledge, rising consumer demand, and supportive policy frameworks (Latha, 2024; Ministry of Finance, 2025; Priyanka et al., 2024; Sharma et al., 2024). Concerns over environmental sustainability, food safety, and rural livelihoods have reinforced the shift, making organic agriculture both an ecological necessity and an economic opportunity (Avinash & Batra, 2023; Das et al., 2020; Ramesh et al., 2005; Verma et al., 2024). The sector's evolution reflects not only a revival of indigenous practices but also a strategic alignment with modern sustainability goals and international market requirements (Avinash & Batra, 2023; Sankar & Aruna, 2020; Swetha & Karunamoorthi, 2024; Ummyiah et al., 2017; Willer et al., 2026).

The Government of India has played a crucial role in accelerating this growth through targeted initiatives, such as the National Programme for Organic Production (NPOP), the Paramparagat Krishi Vikas Yojana (PKVY), and the Mission Organic Value Chain Development for the North Eastern Region (MOVCDNER). These programmes provide certification, market linkages, and farmer training, while aligning domestic practices with international standards (Ghildiyal & Mallaiah, 2024; Latha, 2024; Ministry of Agriculture & Farmers' Welfare, 2024). The NPOP has established equivalence with the United States Department of Agriculture (USDA) and European

Union (EU) regulations, enabling Indian producers to access premium export markets and maintain credibility through traceability mechanisms. By embedding certification and compliance into national frameworks, India has created a robust institutional foundation that supports both domestic expansion and international competitiveness (Agricultural and Processed Food Products Export Development Authority, n.d.-c; Darjee, 2023; Government of India, 2024).

India's export performance reflects the strength of these arrangements. Between 2015 - 16 and 2024 - 25, organic exports rose from $16,420.55 million to $28,682.43 million, with commodities such as floriculture, fruits, vegetables, oilseeds, cereals, spices, tea, and processed foods gaining prominence (Agricultural and Processed Food Products Export Development Authority, n.d.-a). The United States and European Union remain dominant markets, while Southeast Asia and the Middle East have emerged as new destinations (Agricultural and Processed Food Products Export Development Authority, n.d.-b; Babu & Chaithrakumari, 2024; Kumara et al., 2024). This diversification highlights India's adaptability to shifting global demand and highlights the resilience of its organic sector. Export growth illustrates how certification and compliance mechanisms translate into tangible economic benefits, reinforcing the importance of institutional frameworks in shaping agricultural trade (Das et al., 2020; Latha, 2024; Reddy et al., 2022).

Globally, India has achieved significant milestones. Agricultural data published in 2025 indicate that Asia accounts for 60 per cent of the world's organic producers, with India ranking first in producer numbers and second in total area under organic cultivation (Willer et al., 2026). As of March 2025, the NPOP registered 6.23 million hectares under organic certification, including 3.97 million hectares of cultivable land and 2.26 million hectares of wild harvest zones. Madhya Pradesh (1.01 million hectares) and Maharashtra (1.00 million hectares) lead in organic cultivation, followed by Rajasthan, Gujarat, Odisha, Sikkim, Uttarakhand, Uttar Pradesh, and Kerala. Goa ranks eighteenth in cultivable land and tenth in wild harvest area among the thirty-one states practising organic farming (Agricultural and Processed Food Products Export Development Authority, n.d.-b). These figures illustrate both the scale of India's achievements and the uneven distribution of organic adoption across states.

Sikkim became the world's first fully organic state in 2016, demonstrating the feasibility of large-scale transitions (Avinash & Batra, 2023; Bhutia, 2024; Kaur & Raj, 2023; Latha, 2024; Parikh, 2023; Sharma, 2025). Uttarakhand and Madhya Pradesh have also made substantial progress, supported by state-level policies and institutional frameworks (Malviya et al., 2020; Nimole & Panwar, 2024; Singh et al., 2025; Singh & Gupta, 2024). In contrast, smaller states such as Goa have lagged in terms of area under organic cultivation and readiness for export. Goa's agricultural sector is characterised by small and fragmented landholdings, an ageing farmer population, and declining cultivation intensity (Indian Council of Agricultural Research, 2018). Despite these constraints, the state has expanded its organic footprint through certification in high-value crops such as cashew and mango, as well as indigenous rice varieties like Korgut and Jyoti (Directorate of Agriculture, 2022; ICAR-Central Coastal Agricultural Research Institute, 2016). The Goa State Horticulture Corporation now sources organic vegetables for retail outlets, marking a significant development in consumer engagement. These institutional efforts demonstrate how

targeted interventions can stimulate organic adoption even in regions with structural challenges (Directorate of Planning, Statistics & Evaluation, 2025; Indian Council of Agricultural Research, 2018).

Goa's state's agro-ecological landscape, shaped by the Arabian Sea and the Sahyadri Mountains, supports a diverse range of farming systems. Khazan lands, reclaimed tidal zones managed through bunds and sluice gates, represent a traditional model of integrated rice and fish farming unique to Goa (ICAR-Central Coastal Agricultural Research Institute, 2016; Indian Council of Agricultural Research, 2018). By 2024 - 25, Goa had certified 11,750 hectares of cultivable land and 6,089 hectares of wild harvest zones under the NPOP, producing 7,672 tonnes of organic output. Of this, 7,120 tonnes were exported, generating $ 16.37 million in revenue (Agricultural and Processed Food Products Export Development Authority, n.d.-a). While modest compared to larger states, these figures highlight Goa's potential for niche markets and value-added products. The state's export performance demonstrates how even small agricultural economies can integrate into global organic value chains when supported by certification and institutional frameworks.

Goa's organic strategy integrates horticulture, agro-tourism, and agro-processing to enhance farmer incomes and improve exports. Cashew, black pepper, turmeric, and bananas have gained prominence, while mechanisation has increased in response to labour shortages among smallholders. Marketing channels include cooperatives, private dealers, and local markets. Agro-processing initiatives, such as cashew kernel processing, Feni extraction, and fruit-based products, add value to primary produce. Cottage industries producing papad, pickles, and herbal medicines continue to grow, supported by cooperatives and private enterprises. Institutional reforms, including the establishment of a dedicated Cashew Board aligned with APEDA guidelines, further demonstrate Goa's commitment to expanding organic exports (Directorate of Agriculture, n.d., 2022; ICAR-Central Coastal Agricultural Research Institute, 2016; Indian Council of Agricultural Research, 2018).

Public awareness of health risks and environmental concerns has led to the revival of organic practices. Rising health consciousness, environmental awareness, and preference for chemical-free food have fuelled domestic consumption of organic products (Kalaiarasan & Kavitha, 2024; Sharma & Chandel, 2023; Singh & Dhaliwal, 2025; Tanishka & Mohanasundari, 2021). Urban markets, e-commerce platforms, and institutional buyers such as hotels and wellness centres provide new avenues for organic produce (Dharani & Reshma, 2025; Pawar & Kaushik, 2025). Consumer demand and farmer adaptation drive this revival, illustrating how contemporary agricultural strategies help revitalise ecological heritage. Goa's tourism industry amplifies this demand, linking organic agriculture with sustainable tourism and rural development. The integration of organic farming with tourism not only enhances market opportunities but also contributes to the state's broader sustainability agenda (Dessai, 2023; Hans & Colaco, 2019; Thottekat, 2021). Goa offers a distinctive case for analysis due to its agro-ecological diversity, tourism-driven demand, and emerging policy interest. Examining Goa's agricultural growth provides insights into how small states with limited land can utilise organic farming to achieve sustainable development, biodiversity conservation, and integration with tourism-driven markets.

This paper examines the growth of organic farming in Goa between 2015

and 2025, focusing on certified area, export volume, and value realised from organic food products. It analyses the volatility of these indicators to assess the resilience and sustainability of organic agriculture within India's broader context. By situating Goa's experience within national and global developments, the study contributes to the literature on region-specific organic transitions. It highlights how small states with limited agricultural land can utilise organic farming to achieve sustainable development, biodiversity conservation, and integration with tourism-driven markets. Ultimately, the study provides policymakers and practitioners with valuable insights into the opportunities and challenges of organic farming in Goa, offering guidance on advancing sustainable agriculture across India.

MATERIALS AND METHODS

Study Area and Data Sources

The study focuses on the state of Goa, which plays a significant role in India's organic food production and exports. The paper is based on secondary data collected from 2015-16 to 2024-25 from the National Programme of Organic Production and the Agri Exchange portal of the Agricultural and Processed Food Products Export Development Authority. To achieve the study's objective, various statistical measures, including percentages, compound growth rates, standard deviations, coefficients of variation, and instability index analysis, are applied.

Data Processing and Analytical Tools

The data were coded, tabulated, and analyzed using Microsoft Excel. To examine the growth trends in area, production, and exports of organic food products, we estimated compound annual growth rates (CAGRs) for area, quantity, exports, and value realized using a semi-log exponential model, which is appropriate for time-series growth analysis.

Compound Annual Growth Rate (CAGR)

The exponential growth function has been used to compute the growth rates of area, exports, and the value realized of organic products.

The following formula was used to compute the CAGR for the period from 2015-16 to 2024-25.

$$\boldsymbol{logY_t = a + b.t}$$

Where:

$\mathbf{Y_t}$ = area, quantity of exports, and value realized for organic food products in year t.

a = intercept (log of initial value).

b = regression coefficient representing the growth rate.

t = time variable (1, 2, …, n)

The Compound Annual Growth Rate (CAGR) was derived using the formula:

$$\boldsymbol{CAGR(\%) = [antilog(b) - 1] \times 100}$$ (Dash et al., 2017; S. Kumar & Simran, 2024; Kumar & Singh, 2014; Yadav et al., 2025).

Instability Analysis

The instability in area, exports, and value realized of organic products was assessed using the Cuddy–Della Valle instability index (CDVI), initially proposed by Cuddy and Della Valle (1978). This index is widely regarded as one of the most appropriate measures for examining instability in agricultural production (Dash & Prusty, 2020; Sannyasi et al., 2025). The CDVI is calculated as follows:

$$\boldsymbol{CDVI = CV \times \sqrt{1 - \bar{R}^2}},$$

Where;

CV= Coefficient of Variation (%)

Calculated as;

$$\boldsymbol{CV = \frac{Standard\ Deviation}{Mean} \times 100}$$

$\bar{R}^2$= Adjusted coefficient of determination from the growth regression

Calculated as;

$$\bar{R}^2 = 1 - (1 - R^2) \times \left[\frac{(n-1)}{(n-p)}\right]$$

Where:

n = No. of observations & p = No. of parameters observed in the model

The ranges of CDVI are given as follows (Dudhat et al., 2017; Sihmar, 2014):

Low instability: 0 < CDVI < 15

Medium instability: 15 < CDVI < 30

High instability: CDVI > 30

RESULTS AND DISCUSSION

Table 1 presents the descriptive statistics of Goa's organic cultivation area and export performance from 2015-16 to 2024-25. During this period, the area under organic cultivation, including land under conversion, reached a peak of 21,960.97 hectares, while organic exports reached a maximum of 18,663.46 metric tonnes. The highest export value recorded was ₹143.82 crores. On average, Goa maintained 18,685.57 hectares of organic cultivation annually, exported 9,687.64 metric tonnes, and earned ₹28.10 crores per year, indicating moderate but uneven growth. The positively skewed distribution of organic area and export quantity indicates that most years recorded below-average values, with a few years of exceptionally high performance. In contrast, the negative skewness of export values suggests that, generally, high returns are realized, with occasional decreases below the mean.

Government initiatives, such as the Paramparagat Krishi Vikas Yojana (PKVY), the establishment of a Cashew Board, and the promotion of organic clusters, play a crucial role in encouraging farmers to adopt organic practices (Directorate of Agriculture, 2022; Latha, 2024; Press Information Bureau, 2025). Rising global demand for organic products, combined with premium pricing, further incentivized exporters, as evidenced by Darjee (2023) and Willer et al. (2026). Export facilitation by the Agricultural and Processed Food Products Export Development Authority (APEDA), including certification support and market access, enabled Goa to penetrate niche markets for cashew, coconut, and spices (Directorate of Agriculture, 2022; Directorate of Planning, Statistics & Evaluation, 2025). Nonetheless, certification delays, high compliance costs, and limited farmer awareness, particularly in remote talukas, have periodically constrained export eligibility and adoption rates. Market volatility and stringent residue regulations also posed challenges to export performance (Indian Council of Agricultural Research, 2018; Jadhav et al., 2025).

Table 1. Descriptive statistics for different parameters from 2016 to 2025

Parameters	Minimum	Maximum	Mean	S.D.	Pearson's coefficient of skewness
Area (Hectare)	15,698.98	21,960.97	18,685.57	2,232.36	0.05
Export Quantity (Metric Tonnes)	2,848.30	18,663.46	9,687.64	5,695.52	0.73
Export Value (Crores)	53.66	143.82	109.50	28.10	(0.52)

Source: Authors' computation

Table 2. Compound Annual Growth Rate (CAGR) of organic area, exports, and value realized from Goa (2016-2025)

Parameters	*Beta*	*Antilog Beta*	*CAGR (%)*	*Trend*
Area (Hectare)	*0.02*	*1.02*	*2.17*	*Increasing*
Export Quantity (Metric Tonnes)	*(0.17)*	*0.85*	*(15.35)**	*Decreasing*
Export Value (`Crores)	*(0.03)*	*0.97*	*(2.88)*	*Decreasing*

**Significant at p≤0.05*
Source: Authors' computation

Table 2 and Figure 1 present the growth trends in Goa's total organic farm area since the implementation of the Paramparagat Krishi Vikas Yojana (PKVY) in 2015-16. The area under organic cultivation showed a modest upward trend, with a Beta coefficient of 0.02 and a CAGR of 2.17%, indicating gradual expansion. In 2015-16, the total organic area measured 16,957.59 hectares. The area expanded in 2018-2019 and again in 2023-2024, but it declined notably in 2016-2017 and 2024-2025. The coefficient of determination (R^2 = 0.2782) indicates that the linear trend explains only 27.8% of the variation, suggesting that time alone does not reliably account for the expansion of organic farming. These results suggest that PKVY has contributed to some growth, yet the overall pattern of organic cultivation in Goa remains unstable.

The fluctuations in organic farm area reflect structural challenges, including fragmented landholdings, rapid urbanization, and the conversion of agricultural land for industrial purposes. Additionally, Climate change has led to land degradation, while coastal ecosystems face increasing stress due to rising sea levels and tourism-driven development (Morakar et al., 2023). These findings align with national-level evidence that farmers encounter significant barriers in adopting and sustaining organic practices, including limited institutional support, weak policy frameworks, and insufficient farmer participation (Avinash & Batra, 2023; Ghildiyal & Mallaiah, 2024; Latha, 2024; Parikh, 2023; Reddy et al., 2022; Roychowdhury et al., 2013; Yadav et al., 2025). Sustained institutional commitment, farmer training, certification reforms, and stronger community engagement are critical to stabilise and scale organic agriculture in Goa.

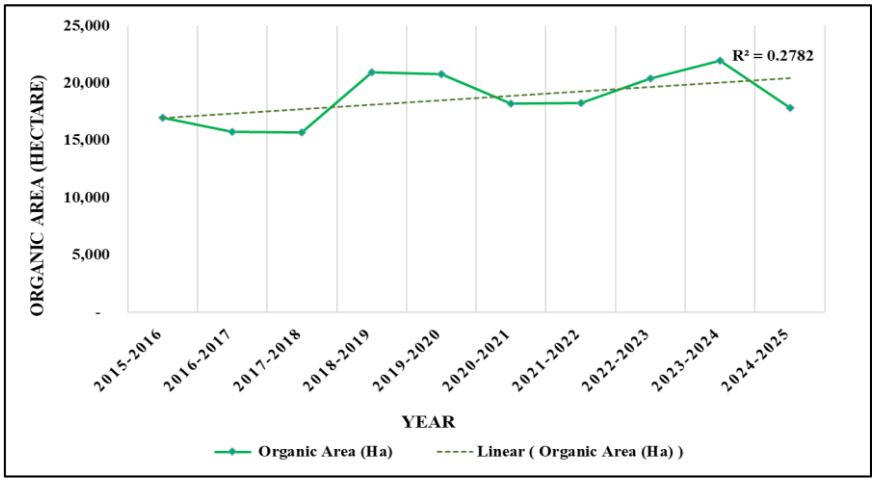


Figure 1. Trends in organic cultivable area in Goa, India (2016 to 2025)

Table 2 and Figure 2 illustrate the trends in Goa's organic product exports, measured in metric tonnes and crores, between 2015-16 and 2024-25. The export quantity declined significantly, with a negative Beta of –0.17 and a compound annual growth rate (CAGR) of –15.35%, while the export value declined with a Beta of –0.03 and a CAGR of –2.88%. Correlation analysis shows that export volumes were moderately associated with PKVY interventions ($R^2 = 0.7591$), while export value exhibited only a weak correlation ($R^2 = 0.0829$).

The decline in both export quantity and value reflects structural and institutional constraints. Certification delays, high compliance costs, and limited farmer awareness, particularly in remote talukas, restrict participation in export markets. Transition-related yield reductions, inadequate infrastructure, and geographical limitations further constrained productivity (Avinash & Batra, 2023; Jadhav et al., 2025; Kowsalya & Rohini, 2024; Surekha et al., 2010). Market volatility and rising compliance costs linked to new European Union certification and transparency regulations intensified the downturn in 2019-20, disproportionately affecting small-scale producers (Golebiewski, 2024; Kowsalya & Rohini, 2024). Despite PKVY's emphasis on certification and cluster formation, Goa's competitiveness remains weaker than that of larger organic clusters in states such as Sikkim and Madhya Pradesh. This outcome aligns with national trends, where India has expanded its organic farming area but continues to struggle with consistent value creation (Babu & Chaithrakumari, 2024; S. Kumar & Simran, 2024; Kumara et al., 2024; Latha, 2024; Patel et al., 2025; Press Information Bureau, 2025; Reddy et al., 2022).

Strengthening farmer-producer organisations and investing in processing and packaging infrastructure are critical to enhancing value realisation. Geographical indication (GI) tagging of niche products could improve market differentiation and competitiveness (Directorate of Planning, Statistics & Evaluation, 2025; Indian Council of Agricultural Research, 2018; Verma et al., 2024). Linking organic produce to eco-tourism and wellness markets presents further opportunities to create diversified demand channels, enabling farmers to secure higher returns and stabilize their export performance (Bhardwaj, 2025; Kaur & Raj, 2023; Sharma et al., 2024).

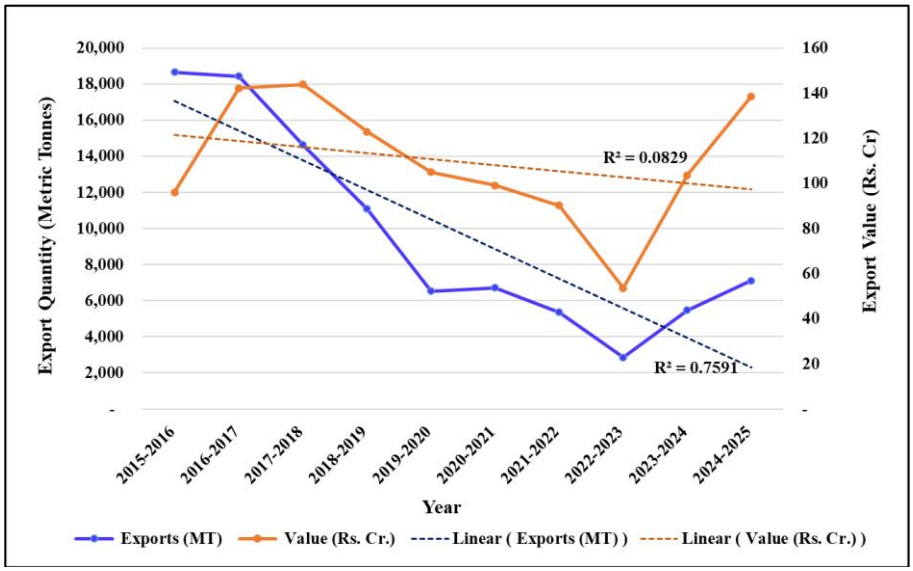


Figure 2. Trends in organic exports quantity and export value from Goa (2016 to 2025)

Table 3. Measures of instability in the organic area, exports, and value realized from Goa (2016 to 2025)

Parameters	*Coefficient of variation (CV)*	$\overline{R}^2$	*Cuddy-Della Valle Instability Index (CDVI)*	*Inference*
Area (Hectare)	*11.95*	*0.90*	*10.75*	*Low Instability*
Export Quantity (Metric Tonnes)	*58.79*	*0.52*	*30.55*	*High Instability*
Export Value (` Crores)	*25.66*	*1.02*	*26.06*	*Medium Instability*

Source: Authors' computation

Table 3 estimates the instability in the area, export quantity, and value realised from organic food products in Goa between 2015-16 and 2024-25. The analysis, based on the Cuddy-Della Valle Instability Index (CDVI), Coefficient of Variation (CV), and Adjusted R^2 values, reveals contrasting patterns across indicators. The area under organic cultivation exhibited low instability, with a CV of 11.95%, a CDVI of 10.75%, and a high Adjusted R^2 of 0.90. These results indicate consistent growth and policy-driven expansion, reflecting long-term land-use decisions and continuity in government support. Export quantity displayed high instability, with a CV of 58.79%, a CDVI of 30.55%, and a relatively low Adjusted R^2 of 0.52. These figures suggest erratic export volumes, driven by certification delays, fragmented supply chains, and limited farmer awareness. Export value demonstrated medium instability, with a CV of 25.66%, a CDVI of 26.06%, and a slightly elevated Adjusted R^2 of 1.02. This pattern indicates that while earnings from organic exports have been more consistently sustained than volumes, they remain vulnerable to market volatility and price shocks.

The stability in cultivated area reflects the impact of sustained institutional support and long-term land-use commitments, consistent with findings from regional studies of organic farming (Avinash & Batra, 2023; Das et al., 2020; Kaur, 2023; Kumar et al., 2022; Rani et al., 2024; Reddy et al., 2022; Roychowdhury et al., 2013). In contrast, the high instability in export quantity highlights structural weaknesses in Goa's organic supply chains. Certification delays, fragmented logistics, and limited farmer awareness, particularly in remote talukas, contributed to erratic export performance. Similar volatility has been documented in national-level analyses of horticultural exports, where quantity instability often exceeds value instability due to supply-side disruptions and inconsistent compliance (Jadhav et al., 2025; Patel et al., 2025; Priyanka et al., 2024; Verma et al., 2024). The export value, although moderately unstable, reflects the challenges of sustaining premium pricing in volatile global markets. Fluctuating demand, certification bottlenecks, and difficulties in maintaining consistent quality and branding have undermined revenue stability. These findings align with broader evidence that organic trade often experiences medium instability due to external market shocks and regulatory pressures (Babu & Chaithrakumari, 2024; Kowsalya & Rohini, 2024; Priyanka et al., 2024; Suthar et al., 2024).

CONCLUSIONS

The study concludes that Goa's organic agriculture sector is experiencing steady expansion in cultivation; however, this growth has not yet translated into consistent export performance. Despite farmers increasingly adopting organic

practices, the region continues to face persistent challenges, including limited access to export markets, inadequate post-harvest infrastructure, and weak market intelligence. These structural gaps have contributed to declining export volumes and values, as well as notable instability. To overcome these barriers, policymakers must strengthen farmer-market linkages, invest in certification and cold chain systems, and promote crop diversification aligned with global demand. Enhancing extension services and empowering farmer cooperatives will be crucial to improving export readiness and ensuring that production gains result in sustainable market outcomes.

CONFLICT OF INTEREST

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Preliminary In Vitro Study of *Lactobacillus spp*. against Fungal Isolates Associated with Skin Lesions in Companion Animals

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Abstract: *The treatment of fungal skin infections in cats and dogs is challenging due to the growing antifungal resistance leading to the exploration of alternative antimicrobial approaches. The present preliminary in vitro study investigated the antifungal activity of Lactobacillus spp. against fungal isolates recovered from skin lesions of cats and dogs. A total of 16 fungal isolates were obtained, presumptively identified as members of Candida, Cryptococcus, Aspergillus, Penicillium, Mucor, and Rhizopus. Nine strains of Lactobacillus were screened for antifungal activity against these pathogens using ditch groove and pathogen inhibition assays. Strains GCK-V1, GCK-PF1, GCK-3, and GCK-6 showed variable inhibitory activity against the fungal isolates, with GCK-V1 and GCK-6 showing comparatively stronger activity in the screening assay. Cell-free supernatants (CFS) and neutralized CFS (nCFS) were subsequently compared to assess whether inhibition persisted after pH adjustment. Several isolates retained or showed increased inhibition after neutralization. These findings provide preliminary evidence of antifungal activity among selected Lactobacillus isolates and warrant further investigation of the factors responsible for the observed inhibition.*

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Introduction:

The skin serves as a protective barrier against environmental pathogens and harbours a diverse microbial community consisting of bacteria, fungi, and yeasts that normally exist in balance with the host immune system. However, disruption of this balance due to allergies, trauma, hormonal disorders, ectoparasites, immune suppression, or poor hygiene can predispose animals to opportunistic infections and microbial dysbiosis (Hensel et al., 2015; Ross et al., 2018).

Fungal pathogens play an important role in dermatological diseases of companion animals and pose significant zoonotic risks. Dermatophytosis, primarily caused by *Microsporum*, *Trichophyton*, and *Epidermophyton* species, is one of the most common superficial fungal infections in dogs and cats (Moriello, 2017). *Microsporum canis* is particularly important because of its high prevalence and zoonotic potential. In addition, Malassezia pachydermatis is frequently associated with chronic dermatitis and otitis externa, particularly in animals with underlying allergic or endocrine disorders (Bond et al., 2020).

The increasing emergence of antifungal resistance among fungal pathogens has made the treatment of skin infections increasingly challenging (Hui et al., 2024). Alternative therapeutic approaches, particularly those based on probiotic microorganisms are now being

considered. Lactic acid bacteria (LAB), especially members of the genus *Lactobacillus*, produce a variety of antimicrobial compounds, including organic acids, hydrogen peroxide, and bacteriocins, which inhibit the growth of pathogenic microorganisms (Gerbaldo et al., 2012). Several studies have demonstrated the antifungal activity of *Lactobacillus spp*. against dermatophytes such as *Microsporum canis* and *Epidermophyton floccosum* (Guo et al., 2012). Likewise, *Lactobacillus casei* isolated from healthy canine skin showed antimicrobial activity against *S. pseudintermedius* isolated from canine pyoderma cases (Diniz et al., 2025).

Despite these promising findings, relatively few studies have investigated the antimicrobial efficacy of *Lactobacillus spp*. against the fungal pathogens associated with skin lesions in companion animals, particularly with respect to the bioactive metabolites responsible for their antagonistic activity. Therefore, the present study aimed to investigate the antifungal activity of *Lactobacillus spp*. against fungal isolates recovered from skin lesions of cats and dogs and to assess their potential for further investigation as sources of antifungal factors.

Methodology

Sample Collection

Sterile cotton swabs were used to collect samples in 15mL capped tubes containing 5 mL sterile saline. The swabs were rubbed on the skin lesions along with hair follicles and then the swabs were suspended into the tubes containing sterile saline. (Brathwaite et al 2025).

Isolation of fungal isolates

The swabs were directly swabbed on the Sabouraud's Dextrose agar (SDA) medium for isolation of yeast and fungal microorganisms. Plates were incubated for 72-96 hours. The isolates were selected from respective sample plates and identified based on colony morphology, microscopic examination and sugar fermentation profiles. (Brathwaite et al., 2025).

Preparation and selection of *Lactobacillus spp*.

Previously identified *Lactobacillus spp*. were screened for antifungal activity against the yeast and mould isolates by diffusion method. *Lactobacillus spp* were grown for 48h in de Man, Rogosa and Sharpe (MRS) broth, and added to the ditch groove/wells created on SDA agar inoculated with fungal isolates. After prediffusion, the plates were incubated at room temperature for 5 days. The zone of inhibition was observed and measured in mm (Iyevhobu, 2022). The *Lactobacillus* strains showing superior activity were selected and further assessed using a pathogen inhibition assay (Lim & Im, 2009).

Preparation of Cell-Free Supernatant (CFS)

Overnight cultures of *Lactobacillus spp*. were centrifuged at 10,000 rpm for 15 minutes to obtain cell-free supernatant (CFS). To compare the inhibitory effect caused by organic acids, the pH of the cell-free supernatant was adjusted to pH 7.0 using sterile NaOH solution. The CFS and neutralized cell-free supernatant (nCFS) was then used for pathogen inhibition assay against the isolated fungal isolates associated with skin lesions.

Screening for Antifungal Activity of *Lactobacillus*

As described by Lim and Im (2009), the pathogen inhibition assay was carried out using CFS and nCFS. 100 µL of overnight grown yeast isolates were inoculated into 10 mL of Sabouraud's Dextrose Broth (SDB) and 100 µL CFS/nCFS were added to it. Tubes were incubated aerobically at 37°C for 24 hours. Microbial inhibition (%) was determined by measuring optical density

(OD) at 600 nm and using equation (1). For mould isolates, antifungal activity was evaluated by determining fungal cell mass after incubation.

$$\text{Inhibition (\%)} = \frac{(Fungal\ growth - Fungal\ growth\ with\ LAB)}{Fungal\ \text{growth}} \times 100$$

Results and Discussion

Sample Collection

Swab samples were collected from skin lesions of cats and dogs using sterile cotton swabs (Fig. 1). A total of 11 skin specimens were collected from 11 individual animals, comprising seven cats (four household cats and three shelter cats) and four shelter dogs. One specimen was collected from each animal. The shelter animals were housed at the Panjim Animal Welfare Society (PAWS), St. Inez, opposite the Hindu Crematorium, Panaji, Goa 403001. Details of the animals and skin lesions are presented in Table 1. All animals included in the study were of Indian native breed, except for one cat that was a Semi-Persian breed (HC4).

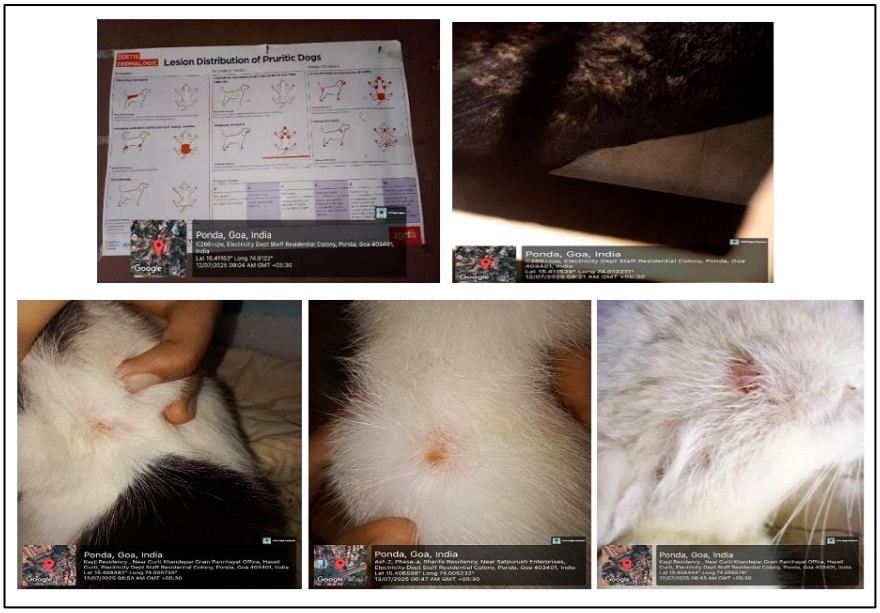


Figure 1: Sample collection

Isolation and Identification of Fungal isolates associated with skin lesions

16 fungal isolates were recovered from SDA plates (Figure 2) Out of the 16 isolates, 6 were identified as moulds, namely SPD1-1, SPD2-1, SPC1-1, SPC2-1, SPC3-1, and SPC3-2, while the remaining isolates were identified as yeasts, including SHC2-1, SHC3-1, SHC4-1, SHC4-2, SSD1-1, and SSD1-2 (Table 2). The isolates were purified by subculturing and preserved as glycerol stocks.

Identification based on colony morphology, lactophenol cotton blue staining, and sugar fermentation revealed the presence of *Candida spp*., *Candida glabrata*, *Cryptococcus spp*., *Aspergillus spp*., *Aspergillus* niger, *Aspergillus* fumigatus, *Penicillium spp*., *Mucor spp*., and *Rhizopus stolonifer* (Table 3-4; Figure 3). *Candida spp*. was predominantly isolated among the yeasts. The occurrence of multiple pathogens from one lesion indicates the polymicrobial nature of skin infections in companion animals. Similar microorganisms have been previously reported in animal skin and wound infections, where opportunistic pathogens commonly colonize damaged skin and contribute to persistent infections (Gnat et al., 2020).

Table 1 Demographic and Clinical Characteristics of Animals Sampled

Group	Animal	Animal ID	Breed	Age (years)	Sex	Skin condition	Lesion characteristics	Body site
House cats	Cat	HC1	Indie	2	Male	Skin infection	Moist	Chin
		HC2	Indie	4.5	Male	Skin infection	Dry	Neck
		HC3	Indie	4	Female	Skin infection	Dry	Back
		HC4	Semi-Persian	5	Male	Skin infection	Dry	Neck
Shelter cats	Cat	SC1	Indie	2	Female	Skin infection	Moist	Nose
		SC2	Indie	3	Male	Skin infection	Dry	Back
		SC3	Indie	2	Male	Skin infection	Dry	Back
Shelter dogs	Dog	SD1	Indie	4	Male	Skin infection	Dry, flaky	Back
		SD2	Indie	3	Male	Skin infection	Dry, patchy	Back
		SD3	Indie	4	Male	Skin infection	Dry lesions	Back
		SD4	Indie	3	Male	Skin infection	Dry	Back, above tail

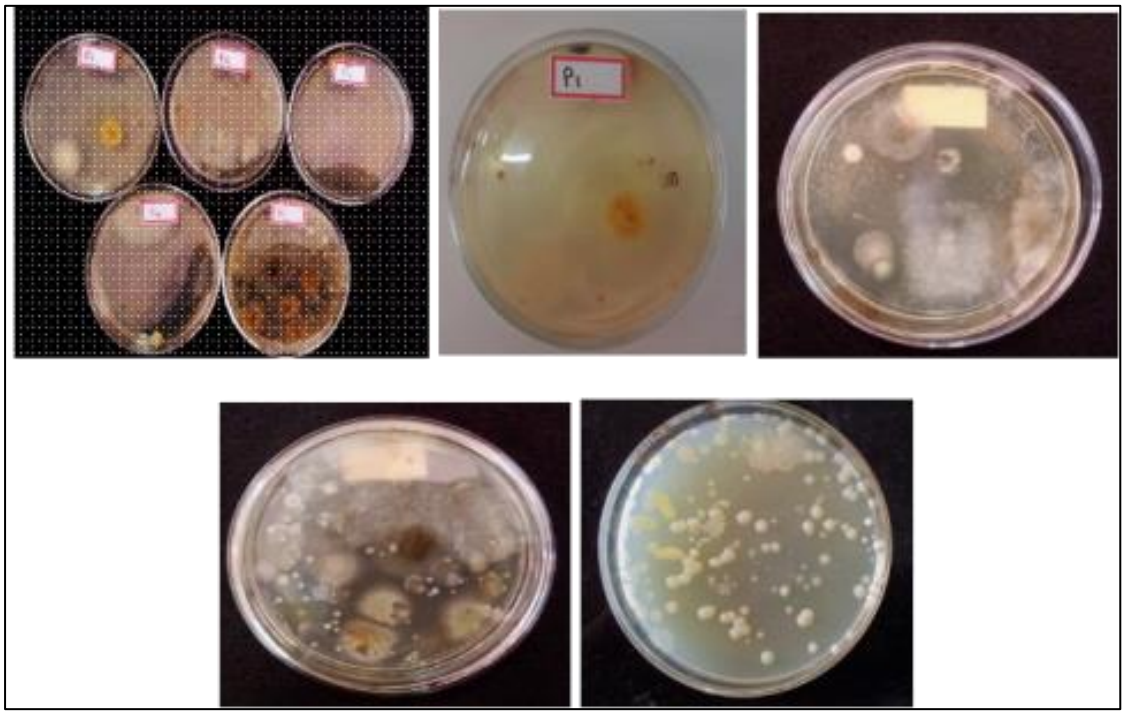


Figure 2: Samples inoculated on SDA plates

Table 2 Colony Characteristics of Fungal Isolates

Isolates	Shape	Size	Colour	Elevation	Margin	Surface texture	Opacity	Consistency	Cell morphology
SPD1-1	Irregular	3mm	White	Raised	Filamentous	Cottony	Translucent	Dry Spores	Septate hyphae with conidial heads
SPD2-1	Irregular	2.5mm	White-Brown	Raised	Filamentous	Wax	Translucent	Dry	Broad aseptate hyphae with sporangia
SPC1-1	Irregular	2mm	White-Pink	Raised	Fibrous	Cottony	Translucent	Dry	Septate hyphae with branched conidiophores (brush-like)
SPC2-1	Irregular	2mm	White	Raised	Fibrous	Velvety	Translucent	Dry	Broad aseptate hyphae with spherical sporangia
SPC3-1	Irregular	2mm	White-Black	Raised	Fibrous	Cottony	Translucent	Dry Spores	Septate hyphae with black conidial heads
SPC3-2	Irregular	4mm	White - Green	Raised	Fibrous	Cottony	Translucent	Dry	Septate hyphae with columnar conidial heads
SPD1-2	Circular	Pinpoint	White	Convex	Round	Smooth	Opaque	Shiny	Oval budding cells
SPD2-2	Circular	0.5mm	Cream	Convex	Round	Smooth	Opaque	Shiny	Encapsulated round to oval budding cells
SPC1-2	Circular	1mm	Cream	Flat	Round	Smooth	Opaque	Shiny	Small oval budding cells
SPC2-2	Circular	3mm	White	Flat	Round	Smooth	Translucent	Mucoid	Oval budding cells
SHC2-1	Circular	3mm	White	Convex	Round	Smooth	Opaque	Butyrous	Oval budding cells
SHC3-1	Circular	1.5mm	White	Flat	Round	Smooth	Translucent	Mucoid	Oval budding cells
SHC4-1	Circular	1mm	White	Concave	Round	Smooth	Transparent	Butyrous	Oval budding cells
SHC4-2	Circular	1mm	White	Concave	Round	Smooth	Opaque	Mucoid	Encapsulated round to oval budding cells
SSD1-1	Circular	1mm	Yellow	Convex	Round	Smooth	Opaque	Butyrous	Small oval cells
SSD1-2	Circular	1mm	White	Flat	Round	Smooth	Opaque	Butyrous	Oval budding cells

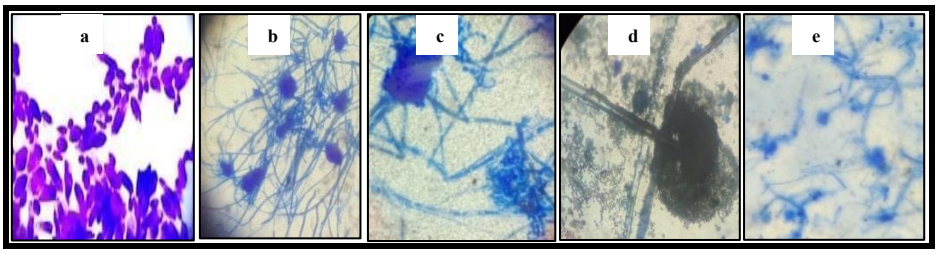


Figure 3 Microscopic characteristics of fungal isolates: *Candida spp*. (a), *Aspergillus spp* (b), *Penicillium spp*. (c), *Aspergillus niger* (d), and *Mucor spp*(e).

Table 3 Sugar Fermentation Profiles of Yeast Isolates Used for Identification

Isolates	SUGARS					
	GLU	LAC	MANN	SUC	XYL	MAL
SPD1-2	+	-	-	+	-	+
SPD2-2	+	-	-	-	-	+
SPC1-2	+	-	-	-	-	-
SPC2-2	+	-	-	+	-	+
SHC2-1	+	-	-	+	-	+
SHC3-1	+	-	-	+	-	+
SHC4-1	+	-	-	+	-	+
SHC4-2	+	-	-	-	-	+
SSD1-1	+	-	-	-	-	-
SSD1-2	+	-	-	+	-	+

Key: + → Positive - →Negative
Lac – Lactose Xyl – Xylose Man – Manitol
Suc – Sucrose Glu – Glucose Malt – Maltose

Table 4: Identification of Yeast and Mould Isolates

Isolates	Identification	Isolates	Identification
SPD1-1	*Aspergillus spp.*	SPC1-2	*Candida glabrata*
SPD2-1	*Rhizopus stolonifer*	SPC2-2	*Candida spp.*
SPC1-1	*Penicillium spp.*	SHC2-1	*Candida spp.*
SPC2-1	*Mucor spp.*	SHC3-1	*Candida spp.*
SPC3-1	*Aspergillus niger*	SHC4-1	*Candida spp.*
SPC3-2	*Aspergillus fumigatus*	SHC4-2	*Cryptococcus spp.*
SPD1-2	*Candida spp.*	SSD1-1	*Candida glabrata*
SPD2-2	*Cryptococcus spp.*	SSD1-2	*Candida spp.*

Procurement of LAB's

Previously identified *Lactobacillus spp*. used in this study are listed in table 5. Purity was checked by subculturing on MRS agar.

Screening of antifungal activity of *Lactobacillus spp*.

Among the tested isolates for antifungal activity, GCK-V1 and GCK-6 exhibited comparatively stronger antifungal activity, while GCK-3 showed the least inhibition against most fungal isolates (Table 6). GCK-V1 produced inhibition zones ranging from 1–11 mm, with highest activity against SPC1-1 (11 mm), SPC3-2, and SHC4-1 (10 mm each). GCK-PF1 showed moderate activity with inhibition zones ranging from 1–7 mm. GCK-3 demonstrated limited antimicrobial activity, except against SPC2-2 (9 mm) and SHC4-1 (7 mm). Among all isolates, GCK-6 showed the highest antimicrobial activity with inhibition zones ranging from 1–25 mm. Maximum inhibition was observed against SPD2-1 (25 mm), followed by SHC4-2 (20 mm), SHC4-1 (16 mm), and SSD1-2 (15 mm).

The results indicate strain-specific antimicrobial activity of *Lactobacillus spp*. against skin isolates. The stronger inhibition shown by GCK-V1 and GCK-6 suggests the production of potent antimicrobial metabolites such as organic acids and bacteriocin-like compounds.

Table 5 *Lactobacillus spp*. Used for Antifungal Screening

Isolate	Strain	Accession number
NPe6	*Lactiplantibacillus plantarum* GCK-3	PX872199
NPe1	*Lactiplantibacillus plantarum* GCK-6	PX872202
V6	*Lactiplantibacillus plantarum* GCK-V1	PV991371
PF1	*Lactiplantibacillus plantarum* GCK-PF1	PV991372
B1-1	*Lactiplantibacillus plantarum* GCK-B1	PX557986
B2-2	*Lactobacillus brevis* GCK-B2	PX557987
B2-3	*Lactiplantibacillus plantarum* GCK-B3	PX557988
B2-4	*Lactiplantibacillus plantarum* GCK-B4	PX557989
V11	*Lactiplantibacillus plantarum* GCK-V3	PV991373

Table 6 Antifungal activity of *Lactobacillus spp*. against isolates associated with skin lesions

isolates associated with skin lesions	***Lactobacillus spp* Zone of inhibition (mm)**			
	GCK-V1	**GCK-PF1**	**GCK-3**	**GCK-6**
SPD1-1	9	0	1	2
SPD2-1	7	7	3	25
SPC1-1	11	2	1	1
SPC2-1	8	0	1	2
SPC3-1	0	1	2	0
SPC3-2	10	3	1	0
SPD1-2	3	2	3	6
SPD2-2	1	2	2	2
SPC1-2	6	0	0	1
SPC2-2	5	6	9	7
SHC2-1	3	5	5	6
SHC3-1	4	2	1	3
SHC4-1	10	2	7	16
SHC4-2	7	1	4	20
SSD1-1	1	0	0	0
SSD1-2	2	1	2	15

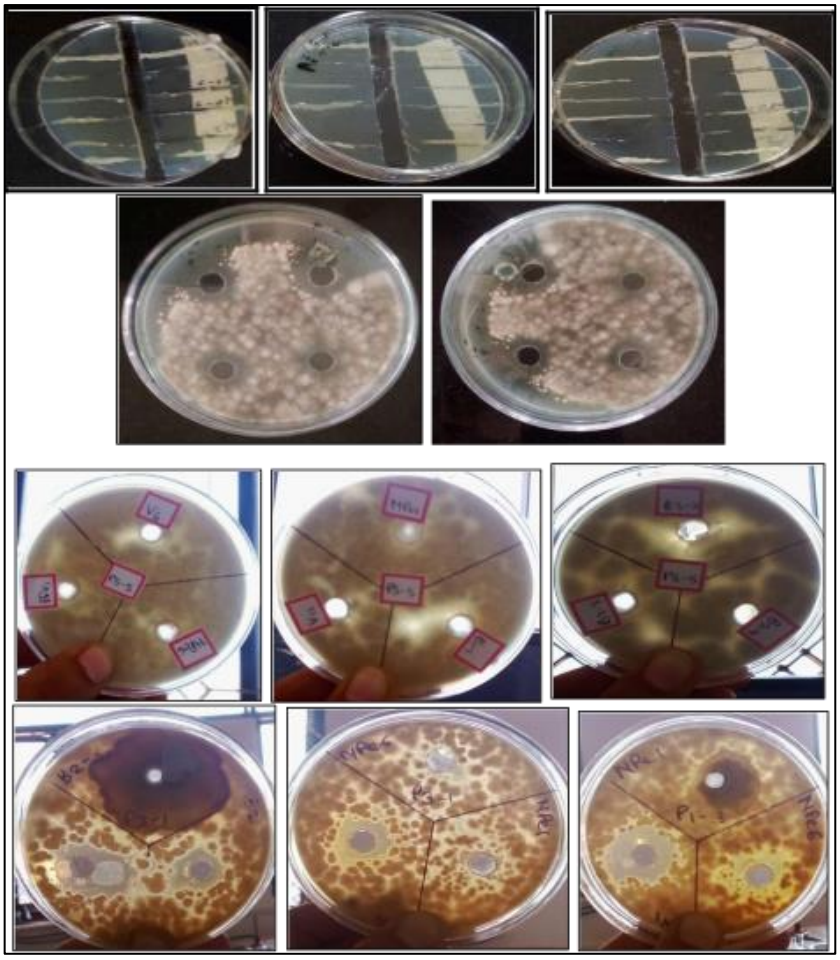


Figure 4 *Lactobacillus spp*. Antifungal activity against fungal isolates

Identification of metabolites responsible for antimicrobial activity

To confirm that the inhibitory effect was not due to the low pH, the pathogen inhibition assay was carried out using untreated CFS and neutralized CFS (pH 7) of *Lactobacillus* isolates. Considerable variations in antimicrobial activity were observed among the two, indicating that multiple metabolites contributed to pathogen inhibition (Table 7).

Comparison between untreated and neutralized supernatants revealed that several *Lactobacillus* isolates retained or even showed enhanced antimicrobial activity after pH neutralization (Figure 5). Increased inhibition percentages were particularly observed against fungal isolates such as SPD2-2, SPC2-2, SHC4-2, SSD1-1, and SSD1-2. The enhanced activity of neutralized supernatants suggests that the inhibitory effect was not solely due to organic acids produced during fermentation. Similar observations have been reported by Ouwehand and Vesterlund (2004), who stated that LAB produce a variety of antimicrobial metabolites capable of inhibiting both bacterial and fungal pathogens. Metabolites such as bacteriocins, hydrogen peroxide, and short-chain fatty acids play an important role in antibiosis. Bacteriocins create simultaneous stress in the target organism which prevents the development and spread of resistance through a single genetic mutation in the pathogen (Acedo et al., 2018).

The strong inhibitory activity shown by isolates GCK-6 and GCK-V1 suggests that these isolates warrant further investigation for their antifungal potential. Given the increasing concern regarding antimicrobial resistance and

recurrent infections in companion animals, naturally produced antimicrobial factors from lactic acid bacteria may represent a promising area for future research (Arena et al., 2016; Hossain et al., 2024). However, the present study provides only preliminary in vitro evidence of antifungal activity, and the specific factors responsible for the observed inhibition need to be identified. Further studies involving characterization of the active compounds and evaluation in appropriate biological models are required to determine their potential application in the management of skin infections in cats and dogs.

Table 7 Percentage Inhibition of Fungal Growth by Cell-Free Supernatants (CFS) and Neutralized Cell-Free Supernatants (nCFS) of Selected *Lactobacillus spp.*

Isolates	Microbial inhibition (%)							
	GCK-V1		GCK-PF1		GCK-3		GCK-6	
	CFS	nCFS	CFS	nCFS	CFS	nCFS	CFS	nCFS
SPD1-1	3.21	4.58	5.12	2.94	4.86	6.11	3.45	5.27
SPD2-1	5.84	2.73	4.91	3.88	6.23	5.47	4.12	3.65
SPC1-1	2.68	3.92	3.41	4.26	5.17	3.84	4.73	5.18
SPC2-1	4.96	5.13	6.02	4.17	3.74	5.68	5.91	4.52
SPC3-1	3.57	6.24	4.83	5.76	6.38	4.91	3.88	5.34
SPC3-2	5.19	4.85	3.96	5.22	4.64	6.07	5.37	4.69
SPD1-2	0	19	4.17	15.73	19.77	16.53	7.29	55.11
SPD2-2	5.31	55.61	3.19	44.92	1.06	70.22	11.7	62.35
SPC1-2	14.52	8.54	16.22	24.72	17.02	32.43	20.51	18.82
SPC2-2	13.59	29.23	3.85	25.32	6.77	43.85	10.67	65.32
SHC2-1	56.66	0.83	13.33	30	50	18.33	20	2.5
SHC3-1	8.13	1.32	26.74	8.87	17.46	45.13	29.07	34.33
SHC4-1	6.94	2.22	13.89	19.25	5.56	28.15	1.38	10.37
SHC4-2	10.12	23.13	16.47	19	12.63	12.67	7.59	24.67
SSD1-1	21.97	43.19	27.43	41.05	24.12	48.45	19.22	45.26
SSD1-2	30.33	39.46	47.11	19	19	35.18	58.46	53.48

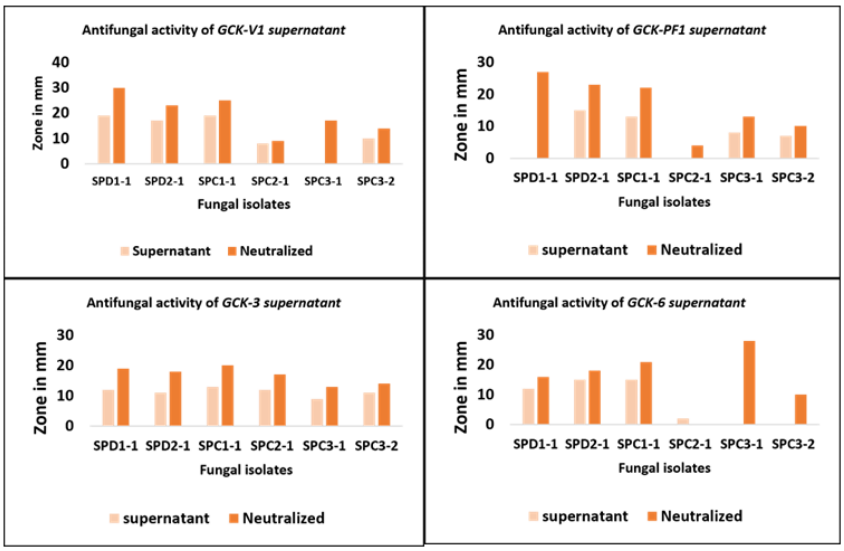


Figure 5 Antifungal activity of *Lactobacillus spp*.

Conclusion

The present study characterized the culturable fungi associated with skin lesions of cats and dogs. The antifungal activity of selected *Lactobacillus* strains was subsequently evaluated against the recovered fungal isolates, including *Moraxella spp*., *Acinetobacter spp*., *Klebsiella spp*., *Candida spp*., *Cryptococcus spp*., *Aspergillus spp*., and *Rhizopus stolonifer*. The Lactobacillus strains exhibited varying degrees of antifungal activity against the fungal isolates, with GCK-V1 and GCK-6 showing comparatively stronger inhibitory potential. Neutralization of cell-free supernatants did not eliminate the inhibitory activity in several cases, suggesting that the observed antifungal effect was not attributable solely to the acidic pH of the supernatants. These findings provide preliminary in vitro evidence of antifungal activity among selected *Lactobacillus* isolates associated with animal skin samples. Further studies involving characterization and purification of the active factors, followed by appropriate biological evaluation, are required to determine their potential application in veterinary settings.

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Ethical considerations and animal welfare: Samples were collected from pre-existing skin lesions and were not obtained through experimental infection or any invasive procedure. Superficial swabs were collected using standard microbiological procedures with minimal restraint, while avoiding additional pain. Sampling was discontinued if an animal showed signs of distress. No procedures were performed to induce disease or injury for the purposes of this study.

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Thermodynamic and Statistical Mechanical Perspectives on Protein-Ligand Binding: Insights from Isothermal Titration Calorimetry

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Abstract: *The interactions between biomolecules, especially protein-ligand interactions, play key roles in many biological phenomena including enzymatic reactions, signaling pathways and other molecular recognition events. Although extensive investigations have been conducted to describe the interaction characteristics using thermodynamic parameters on a macroscopic scale, there has been no adequate understanding of the binding process from a physical viewpoint. The purpose of the current study is to develop a unified theory of biomolecular binding by merging the conventional thermodynamic approach with the notions of Statistical Thermodynamics and Energy Landscape Theory. This article describes fundamental thermodynamic aspects of binding in light of changes in Gibbs free energy (ΔG), enthalpy (ΔH) and entropy (ΔS). Also considered in the present work is the technique of Isothermal Titration Calorimetry (ITC), which enables direct measurement of thermodynamic parameters. The temperature dependence of binding and the role of heat capacity change (ΔCp) in connecting thermodynamics with structural and solvent-related effects are also discussed. One of the main aspects of this review article is the physical interpretation of entropy based on statistical thermodynamics, wherein binding is viewed as a process that transitions from an ensemble of high entropy to a more limited, organized ensemble. In addition, Energy Landscape Theory has been employed to further explain binding as a transition from an ensemble to a low-energy and thus stable state, in the form of a funnel. The significance of these theories in terms of rational drug development will also be addressed here. The purpose of this review is to go beyond describing phenomena to interpreting them using thermodynamics and thus moving from a merely descriptive stage to one that provides a physically meaningful explanation.*

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INTRODUCTION

The term 'biomolecular binding' can be considered synonymous with molecular recognition, as this biological process represents the selective interaction between biological macromolecules and their partners, ranging from simple ions to highly complex molecules, such as proteins and nucleic acids, leading to the formation of non-covalent complexes (Du et al., 2016). Non-covalent complexes are characterized by the burial of solvent-accessible surfaces and the formation of networks of non-covalent interactions, such as hydrogen bonds, van der Waals interactions and electrostatic interactions (Du et al., 2016). Two key

factors govern the binding process: specificity which enables a receptor to recognize the ligand from a large number of similar molecules and affinity, which characterizes the stability of complex formation through the reaction's thermodynamics (Xie et al., 2016).

Biological interactions represent an integral part of many vital processes occurring in living organisms, such as replication, metabolism and signal transduction (Du et al., 2016). Biomolecular interactions are crucial for maintaining of biochemical processes in living cells. On the level of applied biology, biomolecular interactions underlie the functioning of pharmaceutical drugs, whose effectiveness relies on their ability to selectively recognize target proteins (Claveria-Gimeno et al., 2017). Thus, the study of protein-ligand interaction represents an important area of scientific research.

Significant progress has been made in the field of structural biology that provides insight into the structure of proteins. Nevertheless, structural biology alone is not sufficient to describe the mechanisms of functioning macromolecular function. For instance, the stability and spontaneity of molecular recognition require a thermodynamic approach that quantitatively characterizes the contributions responsible for the formation of a protein complex (Onuchic et al., 1997). Binding is governed by Gibbs free energy (ΔG), which results from the enthalpic and entropic contributions (ΔH, ΔS). Isothermal Titration Calorimetry (ITC) is one of the techniques widely used to measure thermodynamic parameters of biomolecular interactions.

However, despite the extensive use of ITC in various investigations, there remains considerable scope for a detailed understanding of thermodynamic data at the molecular level (Falconer et al., 2021). Often, research works concentrate only on revealing parameters related to the binding affinity and enthalpy. There is no attempt made to explain the nature of the interactions between biomolecules. Notably, it is often assumed that entropy can be obtained from the experimental values of other parameters. However, there should be a further study based on the combination of thermodynamics and statistical mechanics together with Energy Landscape Theory (Sharp & Matschinsky, 2015).

Principles of Biomolecular Interactions

Molecular Recognition

Molecular recognition refers to the process by which two biological molecules interact and form a stable association through non-covalent interactions (Du et al., 2016). Such an interaction is responsible for biological processes ranging from cell replication and metabolism to signal transduction. The main factors involved in molecular recognition are specificity and affinity. The former makes the target molecule recognizable among numerous other potential ligands, whereas the latter refers to the strength of the association (Xie et al., 2016).

From chemical perspective, the mechanism of molecular recognition involves a decrease in surface area and the establishment of a variety of weak interactions. They include hydrogen bonds, van der Waals interactions, and electrostatic interactions (Du et al., 2016; Pierce et al., 1999).

Protein-Ligand Interaction

Protein-ligand interactions are important for biological function because proteins use them for regulatory, catalytic and structural purposes. A ligand can be an ion, metabolite, nucleic acid, or any other protein (Du et al., 2016). The reaction involved in the process of interaction can be represented in the following way:

$$P + L \rightleftharpoons PL$$

It can be analyzed in terms of Gibbs free energy change, which can be expressed in the following way:

$$\Delta G = \Delta H - T\Delta S$$

where

ΔH – enthalpy change,

ΔS – entropy change,

T – absolute temperature (Du et al., 2016; Suppavorasatit, 2012).

A negative value of ΔG denotes a spontaneous and energetically fovorable reaction. Affinity is determined in terms of the association constant (K_a) (Callies & Daranas, 2016).

Models of Molecular Interaction

Current approaches to molecular interactions range from early static concepts to dynamic models.

- **Lock and Key Model**

Fischer lock-and-key model of molecular recognition relies on the structural complementarity of the interaction partners. In other words, it postulates a relatively rigid structural complementarity of the protein binding pocket and its ligand. According to this classical concept, the predetermined shape of the binding pocket complements that of the ligand, thus permitting the selective recognition. It is true that the solvent reorganization and entropy contributions might play an important role in binding energetics, but they should not be considered as part of the lock-and-key model (Du et al., 2016; Kumar et al., 1999).

- **Induced Fit Model**

This approach developed by Koshland and involves changes in the conformation of the protein due to ligand binding (Du et al., 2016). Such changes help improve complementation of the protein and the ligand and are associated with enthalpy gain.

- **Conformational Selection Model**

In accordance with the idea of Energy Landscape Theory, molecules interact within a framework of different conformations. Conformers that correspond to the shape of the ligand get selected during interaction (Onuchic et al., 1997; Kumar et al., 1999).

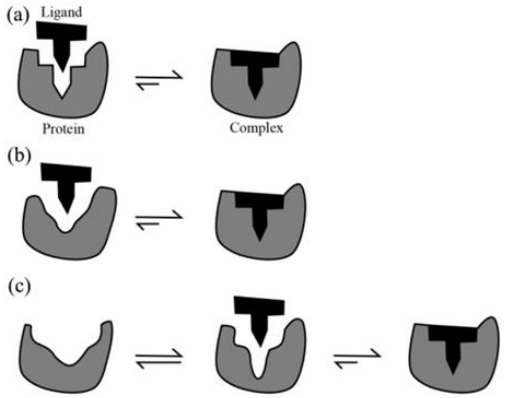


Figure 1 : Schematic illustrations of the three protein-ligand binding models: (a) Lock-and-key; (b) Induced fit; and (c) Conformational selection (Du et al., 2016).

Thermodynamic Basis of Binding

- **Gibbs Free Energy (ΔG) and Binding Affinity**

It is well known that thermodynamics governs biological interactions; Gibbs free energy serves as the main criterion for defining the feasibility and stability of binding processes. A negative ΔG is required for spontaneous interaction under conditions of constant temperature and pressure (Du et al., 2016; Xie et al., 2016).

Binding affinity and Gibbs free energy change are related via the van't Hoff equation:

$$\Delta G = -RT \ln Ka$$

Where,

R - universal gas constant;

T - absolute temperature;

K_a - association constant (Callies & Daranas, 2016).

Because of the logarithm, relatively small changes in ΔG may affect the Ka value significantly: a shift of ΔG by 1.4 kcal/mol results in a 10-fold Ka increase (Freire, 2008).

Gibbs free energy consists of enthalpic and entropic parts:

$$\Delta G = \Delta H - T\Delta S$$

Where,

ΔH - enthalpy change and

ΔS- entropy change of the system (Suppavorasatit, 2011).

- **Enthalpy (ΔH): Driving Interactions**

Enthalpy describes the overall heat changes during formation/disruption of non-covalent interactions, such as hydrogen bonding, van der Waals forces and electrostatic interactions (Du et al., 2016; Brown, 2009). The enthalpy will be negative in cases where interaction formation contributes more than the initial bond breaking.

One of the factors that contributes to the enthalpy change is the desolvation penalty, the energy cost required to disrupt the interactions of polar residues with water molecules that solvate them. These interactions are usually stable and need a relatively high amount of energy to break (up to 8-10 kcal/mol at RT) (Freire, 2008). Therefore, it is important to optimize the interactions inside the binding site and overcome the penalty.

High enthalpic optimization of interactions is associated with high specificity/selectivity in drugs due to geometric requirements (Claveria-Gimeno et al., 2017; Freire, 2008).

- **Entropy (ΔS): Molecular Flexibility**

From a thermodynamic point of view, entropy is the distribution of energy across different molecular degrees of freedom. It can be defined using the concept of molecular flexibility and configurational freedom (Du et al., 2016; Claveria-Gimeno et al., 2017). The entropy of a substance can be expressed in terms of the number of accessible molecular configurations according to the Boltzmann equation:

$$S = k_B \ln \Omega$$

Where,

k_B is the Boltzmann constant and

Ω is the number of accessible configurations (Sharp & Matschinsky, 2015).

In the context of binding, the total entropy change can be considered as consisting of three components:

- **Solvent Entropy (ΔS_{solv})**

Usually favorable and results from the release of ordered water molecules surrounding hydrophobic surfaces into the bulk solvent (hydrophobic effect) (Du et al., 2016; Freire, 2008).

- **Conformational Entropy (ΔSconf)**

Unfavorable results from the loss of molecular flexibility due to the increased rigidity of the protein-ligand complex (Du et al., 2016).

- **Rotational/Translational Entropy ($\Delta S_{r/t}$)**

Always unfavorable and results from the decrease in rotational/translational mobility in a protein-ligand complex compared to free molecules (Du et al., 2016).

Therefore, binding is associated with a restriction of molecular freedom of movement, indicating a shift from a flexible to an inflexible configuration.

Enthalpy–Entropy Compensation

One characteristic feature of biomolecular interactions is enthalpy–entropy compensation (Daranas, 2021). It implies that the formation of favorable changes in one thermodynamic quantity occurs at the expense of unfavorable changes in another quantity. For example, the increase in enthalpy is compensated by the loss of molecular flexibility (i.e., the formation of additional interactions results in a larger negative value of entropy).

It seems to reflect the process of "structural tightening" (Claveria-Gimeno et al., 2017; Brown, 2009), where increased interaction strength is balanced by a reduced degree of configurational freedom. Thus, although the binding affinity increases, the overall gain is relatively small due to the compensatory mechanism.

Accordingly, one of the important goals of rational drug design should be

navigating through and, if possible, optimizing the thermodynamics of the binding process, subject to the constraint of enthalpy-entropy compensation.

Isothermal Titration Calorimetry (ITC)

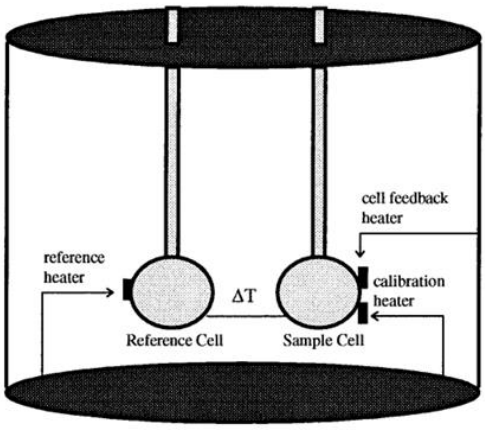


Figure 2 : Schematic diagram of the ITC instrument. (Pierce et al., 1999).

Principle of Isothermal Titration Calorimetry (ITC)

Isothermal Titration Calorimetry (ITC) operates on a thermodynamic basis, meaning that all molecular interactions are accompanied by heat exchange. There will be either a release of heat or an absorption of heat when two molecules bind to one another (Callies & Daranas, 2016). The difference in the amount of heat released or absorbed corresponds to the change in the non-covalent interactions between two molecules during the time the system transitions from its unbound to its bound state (Malvern Instruments Limited, 2014). Under standard pressure conditions, the amount of heat measured corresponds to the enthalpy change (ΔH) that occurs during the interaction (Suppavorasatit, 2011). In order for a system to continue to hold a constant temperature (ΔT=0) between two cells (one containing the ligand solution and the other containing the protein solution), an ITC instrument must have a feedback-controlled power compensation system in place (Pierce et al., 1999; Du et al., 2016). In each experimental trial using the ITC system, incremental amounts of the ligand are injected into a solution of the protein until all available ligand-binding sites are occupied. Each of these injections produces heat signal(s) that can be measured and recorded by the instrument. The power input required by the instrument to maintain thermal equilibrium serves as the primary observable collected by the ITC instrument.

Thermodynamic Parameters from ITC

One of the major advantages of ITC is its ability to provide a complete thermodynamic profile from a single experiment (Brown, 2009). By fitting the binding isotherm using non-linear regression, the following parameters can be directly obtained:

- **Association constant (Ka)**: Determines binding affinity
- **Enthalpy change (ΔH):** Represents heat exchange during binding
- **Stoichiometry (n):** Indicates the number of binding sites

Derived parameters such as Gibbs free energy (ΔG) and entropy (ΔS) can be calculated using thermodynamic relations:

$$\Delta G = -RT \ln Ka$$
$$\Delta G = \Delta H - T\Delta S$$

Additionally, by performing experiments at different temperatures, the heat capacity change (ΔCp) can be determined, providing insights into structural and solvent-related effects (Pierce et al., 1999).

Benefits of Isothermal Titration Calorimetry

There are many benefits of using isothermal titration calorimetry (ITC) compared to other biophysical measurement methods:

- No chemical modification or immobilization of the molecules is needed, so the native interactions are preserved (Pierce et al. 1999)

- The complete thermodynamic characterization,Ka, ΔH, and n, was determined simultaneously in one experiment (Brown 2009)
- Detection of the hidden processes sensitive to proton transfer, solvent reorganization and other water-mediated interactions that are not readily detected by structural methods (Cooper 1999)
- Very sensitive and reliable as it can measure the interactions across a wide range of affinities with very high precision (Du et al. 2016)

Because of these features, ITC creates a complete "thermodynamic fingerprint" of biomolecular interactions, making it a necessary experimental method in both biophysics and drug discovery.

Temperature Dependence and Heat Capacity Change

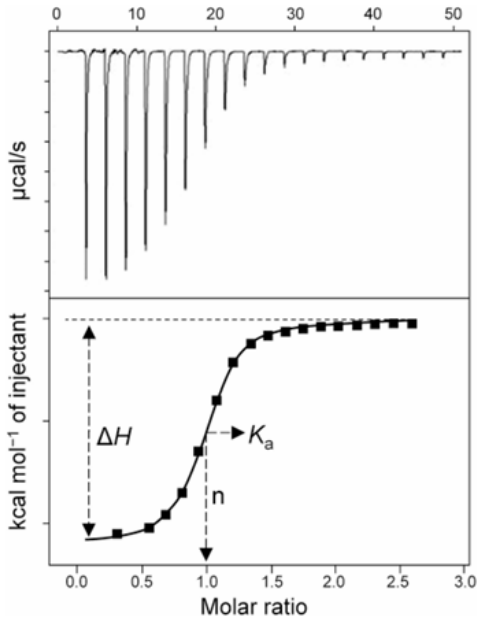


Figure 3 : Representative ITC Data Output and Parameter Extraction (Daranas, 2021).

The Effect of Temperature on Binding

In studying the thermodynamics of biomolecular binding, it is important to remember that enthalpy (ΔH) and entropy (ΔS) depend on temperature (Du, et al., 2016; Callies and; Daranas, 2016). Despite Gibbs' free energy (ΔG) being usually weak to temperature because of enthalpy-entropy compensation, the enthalpy and entropy contributions can vary considerably with temperature (Pierce, et al., 1999). As a result, a single ΔG at 298.15 K insufficient to provide a comprehensive understanding of the structural and energetic changes underlying the binding event (Freire, 2008). At non-zero,heat capacity changes (ΔCp) the ΔG becomes a nonlinear function of temperature, providing maximum binding stability at a characteristic temperature with $\Delta S \approx 0$ (Murphy, 2001; Sosnick & Baxa, 2024).

Heat Capacity Change (ΔCp)

At constant pressure, heat capacity change refers to the temperature rate of change of a system's bonding enthalpy. It can be expressed as follows:

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The author certify that they have no affiliation with or involvement in any organization or entity with any financial interest in the subject matter or materials discussed in this manuscript.

$$\Delta C_p = \left(\frac{\partial \Delta H}{\partial T}\right)_p$$

In ITC experiments, ΔCp is determined from the slope of the ΔH vs. T plot (Pierce et al., 1999; Du et al., 2016). However, to obtain a true energetic characterization of the interaction, it is necessary to take multiple measurements over a series of temperatures (Callies & Daranas, 2016). From a physical perspective, ΔCp quantifies how well a system stores heat energy and can also provide hints about the association between binding and enthalpy fluctuations (Claveria-Gimeno et al., 2017). In general, a negative ΔCp indicates that the interaction becomes more enthalpically driven at higher temperatures, while the entropic

component decreases (Callies and Daranas, 2016).

Structural Interpretation of ΔCp

The change in heat capacity provides a key connection between thermodynamics and structural biology (Du et al., 2016). The magnitude of change in heat capacity is frequently correlated with the change in solvent-accessible surface area (Freire, 2008) occurring with complex formation

- **Hydrophobic Effect:** A large negative ΔCp is an indication of the burial of hydrophobic surfaces. The large negative ΔCp is thought to result from the expulsion of ordered water molecules from the protein surface into the bulk solvent, leading to increased disorder and providing stability to the complex (Pierce et al., 1999; Dill & Bromberg, 2011).

- **Solvent Trapping and Polar Effects:** Deviations from expected ΔCp values may reflect the presence of trapped water molecules or the exposure of polar groups, both of which affect the thermodynamic profile (Callies & Daranas, 2016).

- **Network Flexibility:** ΔCp is correlated with the structural changes between rigid and flexible states within the protein network in more advanced models such as the Distance Constraint Model (DCM) (Jacobs et al., 2003).

Thus, ΔCp can provide insights into the structure of the binding process and relate macroscopic thermodynamic measurements to microscopic molecular rearrangements.

Statistical Thermodynamic Interpretation

- **Entropy and Molecular Configurations**

Statistical thermodynamics connects large-scale thermodynamic properties (or observables) to the small-scale behaviour of molecules (Dill and Bromberg 2011) and this link is made possible via the principle of entropy which reflects not only the amount of disorder (or disruption to the order of molecules) within the system but, in general terms, how many different molecular arrangements exist within the system:

$$S = k_B \ln \Omega$$

(where Ω is the number of accessible arrangements (Sharp and Matschinsky 2015)).

At equilibrium the system has the maximum number (i.e., arrangements) of ways in which a given amount of energy can be distributed amongst its constituent molecules and is therefore in thermodynamic equilibrium (i.e., the system is at maximum entropy).

Entropy as Reduction of Molecular Freedom

The change in entropy due to binding biomolecules is a change in the distribution of molecular 'freedom'. When proteins and ligands are not bound, both have many allowable conformations, and can sample many or all of the different atom arrangements that they may have when they combine. When they attach to each other, their flexibility decreases considerably as they adopt more defined or stable structures It is this loss of configurational freedom that results in a negative change in entropy as they go from a high-entropy/state of no binding to a low-entropy/state of binding (van Holde et al., 2006; Claveria-Gimeno et al., 2017). Although favorable contributions to this loss of freedom from changes in solvent entropy may offset some or all of it, the process usually still results in a net loss or penalty in entropy.

Connecting Macroscopic and Microscopic

With statistical thermodynamics, we can better understand thermodynamic

properties by relating them to their molecular basis. For example, molecular modeling has provided an advanced understanding of entropy's non-additive nature and its dependence on the rigidity of a molecular network through the use of distance-constraint models (Jacobs et al., 2003). Recent research indicates that proteins are best viewed as dynamic systems rather than static structures and that their behavior is better described as populations distributed across conformers (Hilser et al., 2025). The probability of being in each state is determined by a Boltzmann distribution:

$$P_i = exp\ \frac{-\Delta Gi}{RT}$$

In this context, biomolecular binding can be viewed as a shift in population to lower-energy states, providing a physical basis for interpreting of thermodynamic observations.

Energy Landscape Theory:
The Energy Landscape

The energy landscape is a framework for understanding the folding/Bonding of Biological Molecules as a Multidimensional Energy Surface (Onuchic et al. 1997). This Means That All Possible Conformational States of a Molecule exist on the Energy Landscape and Are Associated with Free Energy. The Topography of the Energy Landscape Is Comprised of Several Local Minima and Barriers (Plotkin & Onuchic, 2002), Which Indicates That There Are Competing Forces Acting within the System. The Native Conformation is at the Globally Minimized Free-Energy State and the Intermediate Conformations are Metastable Conformations.

Funnel Model of Binding

The Energy Landscape of Biomolecular Systems has been described as a funnel-shaped surface (Onuchic Et Al. 1997). This means that the system goes from a high free energy, high entropy, to a low free energy, ordered state. Using the Funnel as a model for binding, the unbound protein exists at the top of the funnel, which means that there is a very broad ensemble of conformational states for an unbound protein. Therefore, when a protein binds to a ligand the energy landscape will guide the system toward a more stable (more defined) conformation at the bottom of the energy funnel, resulting in the loss of entropy and the gain of enthalpically stabilizing forces

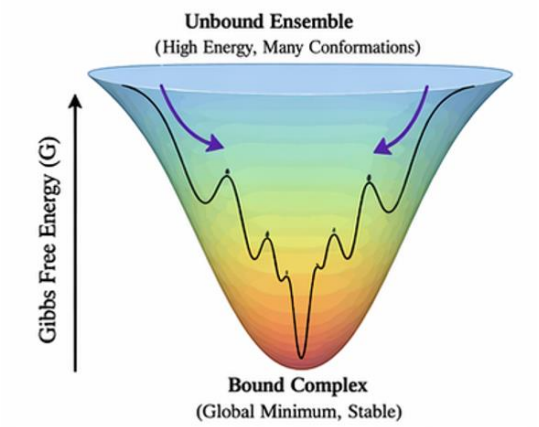


Figure 4: Energy landscape model depicting biomolecular recognition as a funnel-shaped journey toward the native, lowest free energy state.

Relationship with Thermodynamics

Thermodynamic parameters constitute an energy landscape on which to base navigation through this landscape. The free energy (ΔG), represents the total stability of a thermodynamic system, whereas the changes in enthalpy (ΔH) and entropy (ΔS) define the processes by which that system flows to get to its bound state (Plotkin and Onuchic, 2002). Minimal frustration or low levels of potential energy during formation yield the maximum number of favorable native interactions, thereby leading to the most efficient movement toward the global minimum potential energy of a thermodynamic system (Onuchic et al., 1997). The constant-pressure heat capacity (ΔCp) represents a unique property of the

thermodynamic experience that connects thermodynamics with structural transitions throughout development to its native state.

Drug Design Applications

Binding Affinity and Drug Efficiency

It will be important for the drug candidate to bind to its target with adequate affinity, selectivity and binding kinetics if any. The interaction between a majority of drugs and target proteins is usually reversible, while irreversible interaction is the hallmark of certain covalent inhibitors. The strength with which a molecule will bind to another molecule (often referred to as "binding affinity") is a measure of the Gibbs free energy change (ΔG). More negative ΔG values indicate greater stability and improved therapeutic efficacy for that particular drug (Du et al., 2016). Freire (2008) reported a logarithmic relationship between ΔG and the association constant (Ka). This means that when ΔG decreases by just a small amount, the binding affinity increases substantially.

Enthalpy Optimization

Among the principles of modern-day drug design, enthalpy optimization is one of the most important. Modern drugs are designed and tested under this principle, which maximizes strong, highly specific interactions (e.g., hydrogen bonding) with the target. This results in increased selectivity and decreased off-target toxicity (Claveria-Gimeno et al., 2017; Freire, 2008).

Entropy Role in Drug Binding

The element of entropy in drug design has a dual purpose. Favorable solvent entropy increases drug binding, but excessive loss of conformational flexibility (which often occurs when a drug binds tightly) can diminish total binding efficiency. Therefore, achieving a proper balance of enthalpy and entropy is necessary for the development of successful drugs.

Challenges and Constraints

Constraints Associated With ITC Experiments

Though Isothermal Titration Calorimetry (ITC) is known to provide "gold-standard" data on thermodynamic parameters, this technique is constrained by several technical factors. One key issue with ITC experiments is the need for the unitless Wiseman parameter (c = n Ka [M]t) to have values falling in the theoretical range of 1-1000 in order for the binding isotherms to be properly analyzed (Brown, 2009; Callies & Daranas, 2016). This implies that the only values of dissociation constants which can be reliably estimated directly lie within the range of roughly 10−4–10−9 M (Callies & Daranas, 2016). The high-affinity interactions, which occur in the picomolar range, are problematic due to their abrupt transitions. Moreover, ITC is frequently a low-throughput, highly sample-consuming process, as milligram amounts of highly purified proteins are required, which can become expensive when working with challenging target proteins (Claveria-Gimeno et al., 2017; Du et al., 2016). The methodology for fitting ITC data is highly dependent on the accuracy of concentration data, meaning that an error in calculating the quantity of active receptor or ligand will directly affect the calculation of Ka, ΔH, and n (Callies and Daranas, 2016; Malvern Instruments Limited, 2014). Lastly, due to the fact that because the calorimeter measures total heat exchange, it is vulnerable to "hidden variables" such as ionization heat of the buffer, dilution heat, and heat of mixing (Cooper, 1999).

Interpretation Difficulties of Entropy

An important issue in the field of biophysics is how to interpret the

physical nature of entropy data. In many scientific articles, entropy is referred to as a "reduced" value, determined mathematically by subtracting enthalpy from free energy $\left(\Delta S = \frac{(\Delta H - \Delta G)}{T}\right)$ without establishing a link to the dynamics of molecular ensembles (Sharp & Matschinsky, 2015). Another important issue is enthalpy–entropy compensation (EEC), in which the formation of more energetically favorable specific interactions (negative ΔH) leads to an unfavourable decrease in molecular mobility (negative ΔS) (Daranas, 2021). It is argued whether EEC has physical sense or if it is a consequence of experimental error since any uncertainty in the measurement of ΔH produces similar uncertainties in ΔS (Callies & Daranas, 2016; Du et al., 2016). More elaborate models, such as the distance constraint model (DCM), have made it clear that entropy is non-additive in the presence of network rigidity (Jacobs et al., 2003). As such, the amount of lost entropy due to bond formation depends on the constraints already imposed on the protein ensemble and therefore cannot be explained by group additivity (Jacobs et al., 2003). physical nature of entropy data. In many scientific articles, entropy is referred to as a "reduced" value, determined mathematically by subtracting enthalpy from free energy $\left(\Delta S = \frac{(\Delta H - \Delta G)}{T}\right)$ without establishing a link to the dynamics of molecular ensembles (Sharp & Matschinsky, 2015). Another important issue is enthalpy–entropy compensation (EEC), in which the formation of more energetically favorable specific interactions (negative ΔH) leads to an unfavourable decrease in molecular mobility (negative ΔS) (Daranas, 2021). It is argued whether EEC has physical sense or if it is a consequence of experimental error since any uncertainty in the measurement of ΔH produces similar uncertainties in ΔS (Callies & Daranas, 2016; Du et al., 2016). More elaborate models, such as the distance constraint model (DCM), have made it clear that entropy is non-additive in the presence of network rigidity (Jacobs et al., 2003). As such, the amount of lost entropy due to bond formation depends on the constraints already imposed on the protein ensemble and therefore cannot be explained by group additivity (Jacobs et al., 2003).

Need for Integrated Approaches

To advance beyond mere description of observable macromolecular properties, it is crucial to apply an integrative approach incorporates biophysical methods. Even though ITC thermodynamic data have a very high level of precision, they cannot provide information on structural changes at the atomistic level (Claveria-Gimeno et al., 2017). This means it should be complemented by additional orthogonal methods, such as, NMR spectroscopy to estimate local microscopic binding affinity or X-ray crystallography to observe the static structure of the bound complex (Brown, 2009; Pierce et al., 1999). It is also extremely important, for interpreting the total change in heat, to apply computational approaches such as molecular dynamics simulations or free-energy estimations (Du et al., 2016). In addition, the application of global analysis tools enables simultaneous fitting multiple datasets simultaneously, including both direct and reverse titrations conducted at different temperatures, therby increasing the accuracy of thermodynamic parameters (Brown, 2009; Falconer et al., 2021). Finally, tracing the evolution of a system along a funneled energy surface would require a unified approach that combines information about heat obtained from calorimetry with

Boltzmann equation ("counting" the change in configurations) (Onuchic et al., 1997).

Conclusion and Future Perspectives

Isothermal Titration Calorimetry (ITC) has emerged as the "gold standard" for defining the physicochemical aspects of molecular recognition, serving as the sole method for calculating the binding constant (Ka), enthalpy (ΔH), and stoichiometry (n) in a single experiment (Pierce et al., 1999). This type of calorimetic analysis yields a full set of thermodynamic characteristics and serves as a fingerprint of the driving forces stabilizing the interaction (Pierce et al., 1999). The predominance of an enthalpy-driven mechanism of interaction implies that polar contacts have been optimized geometrically, which is extremely important to differentiate between best-in-class and first-in-class drug candidates (Freire, 2008). Additionally, considering the information on temperature dependence, it is possible to determine the change in heat capacity (ΔCp), which provides a definitive structural link for quantifying the burial of hydrophobic surfaces and the expulsion of ordered water molecules into the bulk phase (Claveria-Gimeno et al., 2017).

Relevance of Physical Interpretation

The real potential of contemporary biothermodynamics lies not only in the descriptive analysis of macroscopic variables but also in developing a statistical-mechanical interpretation of experimentally obtained results (Dill & Bromberg, 2011). Unfortunately, there appears to be an underrepresentation of entropy in the scientific literature, where it is treated as a "reduced" characteristic of the process rather than a precise mathematical value representing the number of microscopic states (Sharp & Matschinsky, 2015). Using the well-known Boltzmann equation (S=kBlnΩ), one may "enumerate" the redistribution of accessible microscopic states, therby explaining the nature of "tighter structure" formation during self-assembly (Sharp & Matschinsky, 2015). The combination of the above knowledge with the Energy Landscape Theory allows for describing binding as a transition between different populations of the landscape, from a highly entropic, unbound state to a structurally unique, energetically favorable bound state (Onuchic et al., 1997; Plotkin & Onuchic, 2002). Thus, a quantitative connection between the heat change measured by a calorimeter and driving forces in biological systems is made.

Future Direction

The future of biomolecular binding studies lies in the marriage of precise calorimetric measurementswith sophisticated computational and experimental modeling.

• Multidisciplinary Techniques: For a full atomistic level analysis, ITC must be coupled with NMR to quantify site-specific microscopic binding constants and X-ray diffraction to determine the atomic-resolution structure of the bound molecule (Brown, 2009).

• Network-Rigidity Modeling: Future studies should focus on using computational models such as DCM and COREX to probe the non-linear nature of entropy and the transmission of allosteric signaling across protein networks (Jacobs et al., 2003; Hilser et al., 2025).

• AI and Machine Learning: Protein structure prediction by artificial intelligence techniques like AlphaFold has tremendously increased our capacity for predicting structures, especially those which are close to the ground state or the predominant folded structure. Nevertheless, there is still no

direct information about the temperature-dependent functional states and conformational ensembles obtained from only the structure prediction. Therefore, future work in this field should consider the integration of AI-based structure prediction with simulation and experimental techniques that can capture conformational heterogeneity and dynamics.

• Thermodynamic Range Expansion: By expanding the temperature and pressure parameters to wider regions, the accurate determination of Gibbs free energy curves becomes possible, allowing further study of the heat and cold denaturation processes (Freire, 2008; Sosnick & Baxa, 2025).

In conclusion, while moving from descriptive thermodynamics to predictive biophysics, these viewpoints will play critical roles in optimizing medicines (Falconer et al., 2021).

CONFLICT OF INTEREST

The authors have declared that they do not have any financial or other competing interests which may have affected the results presented in this paper.

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"Setting a Feminist Agenda for a Post Feminist Audience?": An Analysis of Select YouTube Videos of Indian Content Creators

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Abstract: *This paper analyzes five videos from the following YouTube channels namely Vitamin Stree, Kommune India and Unerase Poetry to examine audience reactions to creative content resisting the patriarchy ideology through feminist critical discourse analysis of select comments. It also explores mechanisms of YouTube as a platform that influence circulation and reception of progressive content. In The Rise of the Network Society (2010) Manuel Castells observes that in the age of the new media, the cyber environment poses a significant challenge to identity construction and to find social meaning. A community of followers is an integral part of identity construction of content creators. Quality feminist content can be produced in an attempt to changing people's mindset in a relatively conservative society. However, it does not always yield desired results. In fact, the audience reactions show post feminist sensibility wherein contradictory tendencies of feminism and anti feminism co-exist.*

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INTRODUCTION

The dominant ideology of a society is crystallized in its entertainment forms, particularly, its media. Social media provides an opportunity to further study the deep-rooted conceptions and biases of a society. This study has taken status of women as a parameter to examine gender ideology of a cross section of the Indian society through select YouTube videos from late 2010s, particularly presented in the emergent form of spoken word poetry. The videos have been sourced from three YouTube channels that consciously publish women-centric and progressive content namely Vitamin Stree, Kommune India and Unerase Poetry. Content of women creators resisting patriarchal ideology has been chosen on purpose. The primary texts are of diverse generic nature such as an explainer, a femvertising campaign and three spoken word poems touching upon sensitive issues such as consent, sexual violence, women's pleasure and agency.

The comment section of YouTube videos can prove to be a useful tool to understand reception of feminist content. The videos selected for analysis were published between 2017 to 2019 and have comments concentrated between 2019 to 2021. Around first 100-150 comments arranged in the chronological order were manually read to identify discursive and thematic threads. The reading presents an entanglement of feminist and anti feminist ideas to unravel a postfeminist sensibility. The texts present the women creators as free and autonomous subjects demanding equality, respect and dignity in a patriarchal society. However, the comment section is a mix of applause,

identification with and derogation of the content and its creators.

The research objectives of this paper include firstly, a close reading of select YouTube videos featuring Indian women as content creators to identify recurrent themes. Secondly, understanding nature and impact of YouTube, as a platform, on the format, circulation and reception of the content and thirdly, examining the construction of the primary texts as well as the audience comments from the postfeminist lens through the feminist critical discursive method.

Literature Review and Theoretical Framework

It is vital to look at nature of YouTube as a new media platform before analyzing content published on it. In The Rise of the Network Society (2006) Jan Van Dijk defines new media based on the simultaneous presence of three characteristics that is integration of audio and visual elements, interactivity and use of digital code particularly at the end of the 20th century and the beginning of the 21st century. Hence, they are often referred to as multimedia, interactive media and digital media (9). YouTube resembles television in its integration of audio and visual elements, but being a part of the internet, it has the inherent advantage of interactivity and digital code. Being a social media platform, the audience can determine what they would like to watch and they can even choose to be content creators, either amateur or professional with economic returns. In the present times, YouTube serves dual purpose. It is a common medium of entertainment and information dissemination.

Richard Grusin in "YouTube at the End of New Media" opines that the popularity of the site can be attributed to the fact that it enables better opportunities of mediation, that is, sharing through various platforms such as email, social media, blogs and news sites (65). Henry Jenkins perceives YouTube as a facilitator of convergence culture. It is "a completely networked media environment" (65) with different interconnected media appliances and media interfaces.

Hypermediacy, that is, generating an immediate desire in the user to access a certain piece of content, making them acutely conscious of the act of seeing, and positive affective loops are crucial characteristics of such a convergence culture. YouTube experience is a complex phenomenon such that user preferences are collected and recommendations are generated.

The second aspect of YouTube, observed by Jay David Bolter and Richard Grusin in Remediation: Understanding New Media is that it creates a divergence culture. They note "YouTube serves to exemplify with its ability to be embedded in other media formats, its thousands of channels, its recommendation system and other features of what has come to be called networked media's "long tail"…YouTube produces a divergence of audience and message, temporally and territorially, fostering multiple points" (66).

Jean Burgess and Joshua Green perceive YouTube as "co-creative culture" where there is an inter-connectedness of stakeholders such as professionals and amateur, commercial and non-commercial. They divide the uploaders into four categories, firstly the traditional media companies, secondly the small-to-medium enterprises or independent producers, thirdly, the government organizations and cultural institutions and lastly, amateur users (91) which is a broad term for singular users that include former participants, casual users, active participants, YouTubers and YouTube celebrities (93).

Kubra Sait's "What Women Want" posted on Kommune India is a classic example of co-creative culture. This performance of spoken poetry is a part of Vivel's femvertizing campaign. The

commercial interests can provide impetus to the message of prioritizing women's choice helping it reach wider audience. The media culture developing on YouTube cannot be straight jacketed into purely social, non commercial, user-generated content.

Rosalind Gill in "Postfeminist Media Culture: Elements of a Sensibility" opines that postfeminism is characterized by contradictory elements. On one hand, it shows women as "active, sexually desiring subject[s]" (151), "autonomous agents" (153) while on the other hand, encouraging "performance of femininity" (155), women's obsession over attractive bodies, self-surveillance, conditional agency as objects of heterosexual fantasies, and reinstating sexual difference. Angela McRobbie in "Post feminism and Popular Culture" names this contradiction as double entanglement. Gill points at the "synergy of post feminism and neoliberalism" (164). She asserts that prevalence of feminist content in media does not ensure achievement of feminism's goal of bringing about social change. In fact, this content functions to depoliticize the movement itself. Feminist content is simultaneously detested as well as subsumed in capitalist, consumerist and neoliberal ideology. It is appropriated to serve the neoliberal agenda of thrusting the responsibility decision making, self-regulation and self-invention on the individual by constructing her as an entity beyond politics, influence and constraints.

Michelle Lazar in "Feminist Critical Discourse Analysis" looks at gender as an "ideological structure and practice" based on "presumed naturalness of sexual difference" (373). This method questions power inequality perpetuated as common sense and examines role of language as a semiotic system invested in construction of gender ideology. This method depends upon critical reflexivity and analytic activism to achieve progressive change in the society.

Discussion of Primary Texts

The YouTube channels chosen for analysis namely, Vitamin Stree, Kommune India and Unerase Poetry fall under the second category of uploaders, that is independent producers. Vitamin Stree explicitly states on its "About" page that the focus of the channel is on celebrating women.

Kommune India and Unerase Poetry are spoken word poetry platforms where the poets have gender related issues as the crucial themes of their works. These independent producers support the alternative voices and take on Indian culture primarily exposing the hypocrisies, challenging gender roles and demanding an end to gender discrimination.

Gunnar Iverson, by borrowing Marc Auge's terms, opines that YouTube lies at the crossroads of anthropological place and a transient non place. It is characterized by hypersociality which is based on dual phenomena of sharing and feedback. There is overabundance of information and users indulge in individualized interpretation of the content. Iverson emphasizes "As a social process — unless used in a specific way by a local community — YouTube is characterized by the consumption of information" (351). Indian YouTube channels attempt to weave a collectivity with common cultural references, in this context, certainly a statement against patriarchy and gender discrimination as they set out to redefine gender perceptions. Studying the reception of feminist content on YouTube provides insights about the ideological leanings of the audience and in turn the effectiveness of attempts of progressive creators to bring about change in the societal mindsets.

In the introduction of Michele White's Producing Women: The Internet, Traditional Femininity, Queerness and

Creativity (2015) she underscores Lisa Nakamura's argument of how feminist inquiries about agency and representation could certainly be extended to the internet through examination of approaches of gendering and racializing bodies.

One of the seven social media secrets John Blossom reveals in his book Content Nation : Surviving and Thriving as Social Media Changes Our Work, Our Lives, and Our Future (2009) has to do with the production model of social media. He highlights that the model aims at "mass contextualization in millions of small factories to create and aggregate content again and again in constantly renewable and useful context" (50). He uses the industrial metaphor of factories for content creating platforms. Direct contact with and insights of the audience are essential for a content platform to thrive in the long run. Public comments are a form of enabling feedback on YouTube. Though these comments are not necessarily positive nor is there any way of ascertaining complete transparency about the identities of those commenting, every comment is an instance of hypersociality, hypermediacy, individualization as well as mass contextualization at the same time. As an individual viewer of the content interprets the content for themselves, he or she also contextualizes themselves in the larger discourse about a given topic.

YouTube as a medium is a complex combination of immediacy and hypermediacy. Through YouTube, content creators can successfully bridge psychological distances with their audience. However, the audience also is acutely aware of the medium itself, where they can navigate between multiple videos, submit written responses, choose the next piece of content based on recommendations, share a video on multiple platforms.

In The Rise of the Network Society (2010) Manuel Castells observes that in the age of the new media, the eternal quest of searching for identity and finding social meaning encounters advanced hurdles, particularly the self needs to contend with the overwhelming influence of the internet. Educated urban and semi-urban Indian women have found a safe space for discussion in form of the YouTube channels selected for this study. They have a connected community of dedicated followers that relate to the issues raised in the videos.

Kubra Sait's "What Women Want" is a part of ITC Vivel's campaign #AbSamjhautaNahin. The Hindi hashtag translates to 'No to compromise'. The description of the video highlights the aim of the campaign. "All in hope a collective of young individuals to be equality champions and inspire others for a more gender-equal India". Vivel under the story of the brand projects its commitment to gender equality by stating "The essence of the brand has culminated in its current role in the lives of women today, where they have an equal right to dream, live with respect and be achievers. Vivel inspires them to 'Never Compromise' (Our Story). This video makes a statement about how often women do not find conducive environment to pursue their goals. Their safety, their rights, their choice and their consent are in jeopardy. Kubra asserts "I just want to feel safe…unafraid (Sait 00.00.46). She reflects on society's tendency to impose labels on women, to disapprove any such behaviour that defies prescriptions. Whether it is the unending fight for safety or the struggle to achieve equality at workplace, the path is full of hurdles in terms of biased attitudes, narrow-mindedness, conservative mindsets. Sait appeals "I want to play characters and not want to be labelled as bold, courageous or a path breaker I just want to be able to do my job I want to grow to be ambitious without being apologetic" (Sait, 00.01.50). She hopes that there would be

a comprehensive dialogue about Feminism and not a debate aimed at dismissing the movement in name of man hating or an endeavour to establish supremacy of women. Sait concludes by noting “I want to want. I don't want my wants to be dreams. I want my wants to be needs” (00.02.45) that is there would be a day when basics such as safety, freedom and dignity would not remain abstract dreams but turn into concrete reality.

Jhansi’s “Princesses Don’t Make Chai, Do They?” published by Kommune India is a sarcastic take on parents who pressurize their daughters to marry at a certain age. They do not consider the opinions of their child. For them, marriage and motherhood are the ultimate goals of woman’s life. Narrow-mindedness makes them disapprove of their daughter’s relationship which transgresses the boundaries of class, religion and caste. Jhansi lyrically vents out her rage about the exploitative patriarchal system that encourages evils such as dowry under the garb of gifts “they swipe your parents clean; they kill your every dream because now you are part of their team "Khandan"” (00.03.58). Patriarchy does not acknowledge domestic labour and emotional cost of looking after a family, Jhansi humorously underscores “now they have got a maid for free, making khichdi putting ghee” (00.04.48). Societal expectations of abandoning her identity and accomplishments to transform herself into a housewife comes as a traumatic shock to the speaker and she exclaims in pathos and in rage “leave all my work behind, focus on household crime, goodbye freedom, goodbye choice, no more voice. I have got a Ph.D. this title did not come for free so this is not how it's supposed to be not in a human way” (00.05.37).

Two spoken poetry performances of Priya Malik published by UnErase Poetry titled “Right to Pleasure” and “Swipe Right for Choice” aim at starting a conversation around women’s right to pleasure. The description of the first video states that its goal is to “break down stereotypical image of a woman and her sexuality”. Initially it delves into the grammar of the words choice, consent, pleasure and right. This video commits itself to start a difficult dialogue about the sanctity that is associated with female body in order to deny her the right to pleasure with the hash tag #Mybodyisnotatemple. She poignantly comments “your body is not a temple, neither sacred, nor holy” (00.01.29) “It is a graveyard of societal conventions/ Tombstones inscribed with centuries of shame” (00.01.32). A society that forbids self-pleasure fails miserably in preventing sexual abuse in public as well in the privacy of homes and female genital mutilation. Malik ultimately asserts “it is with our choice and not without our consent, that it is our right to exercise our pleasure and our pleasure to exercise that right” (00.02.27).

Malik’s “Swipe Right for Choice” raises questions about women’s safety and their right to their bodies “According to the age-old belief you do not have agency over your own body. Your body belongs to your parents, your boyfriends, your husbands the perpetrators, the society and even to the government” (00.01.15). Commercial enterprises do not hesitate in turning women’s safety into a viable opportunity by getting a range of products to address the issue however, the society miserably fails in addressing the prejudices and mindset that perpetuates crime. Malik comments ironically “use a pepper spray, a safety rod, a safety torch or even a lipstick shaped flashlight specially created for women's safety” (00.01.32) “while you do not have the right to own your body, it is your duty madam to sanitize it, to safeguard it” (00.01.42).

One of the misconceptions about YouTube that Patricia Lange points out

and would be useful to look at is "YouTube is not a community". Engagement on social media can leave users with a false sense of community. Guillaume Chaslot underscores that AI algorithms of YouTube are meant to generate hyper engagement of users and to maximize the time they spend on the site. This leads to echo chambers or filter bubbles that recommend similar content and isolate users from alternative perspectives thus influence their mindsets and making them inclined in a singular direction.

Hyper engagement can culminate in a YouTube Vortex, urban dictionary defines it as "The event of misplacing time because you are on YouTube and you keep clicking things that look interesting" until eventually you have been completely engrossed and lose track of time. There is, in fact, a need to generate positive affective loops on YouTube.

The comment section on YouTube adds social dimension to the platform as it facilitates interaction. Lange emphasizes that, for many, it has replaced Television, particularly, the youth. YouTube plays role of an archive and even a repository. YouTube facilitates connections that take forms of meetings of like-minded individuals, often content creators and collaborators.

Another misconception about YouTube that Lange notes is "YouTube has exceptional difficulty with anonymous haters". Irrespective of whether the content comprises of a human face or not there have been instances of hateful comments particularly full of stereotypical statements. Many content creators have left YouTube, and an equal number have returned due to the support exhibited by their fans.

Chaslot highlights the fact that hyper engaged users determine the kind of content that gets produced by virtue of more likes and views. If sexist and misogynistic content gets circulated amongst Indian audience, then it speaks for the preferences of hyper engaged users.

Chris Stokal Walker recommends greater intervention on the part of YouTube in monitoring the content through human staff rather than relying heavily on AI. There exists a symbiotic relationship between the astonishment and thrill-seeking audience and the content creators interested in hyper engagement. Hence, YouTube perpetually struggles to tackle the issue of negative affective loops.

Ghoshal quotes Chaslot who opines that the audience at times may not have level of media literacy that the monitoring team might expect and a video, that apparently seems funny, can lead to a disaster. Ghoshal also adds that it is often observed that YouTube takes cognizance of preferences and values of the advertisers for obvious financial reasons over individual content creators. Considering this, support of brands such as Vivel to Sait's "What Women Want" puts her in an advantageous position in terms of circulation of the video as well as in realizing her vision of having positive content on the site.

Taking a look at the comments section of "Feminism is a Problem" published by Vitamin Stree on 29 May 2017 would help in getting better insights in the feedback mechanism of YouTube. The description of the video points out the misconceptions about Feminism, which are largely a result of ignorance. It states "Feminism is that poor kid who's bullied because of her name. She's misunderstood, mocked and rejected without people attempting to get to know her".

The video asserts that Feminism as a word and a movement may mean different things to different individuals but essentially it is "equal rights to all gender identities" (00.01.29). It concludes that there has been misinterpretation of the movement as it "challenges deep seated ideologies"

(4.00). Radicalized imagery has been used to misrepresent it without comprehending its core principles. A snippet of some comments on the video has been used to illustrate the same.

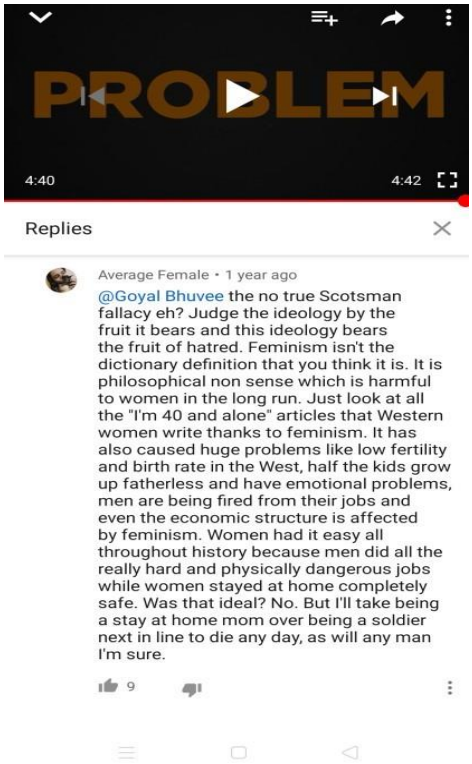


Figure 1: Comment by Average Female

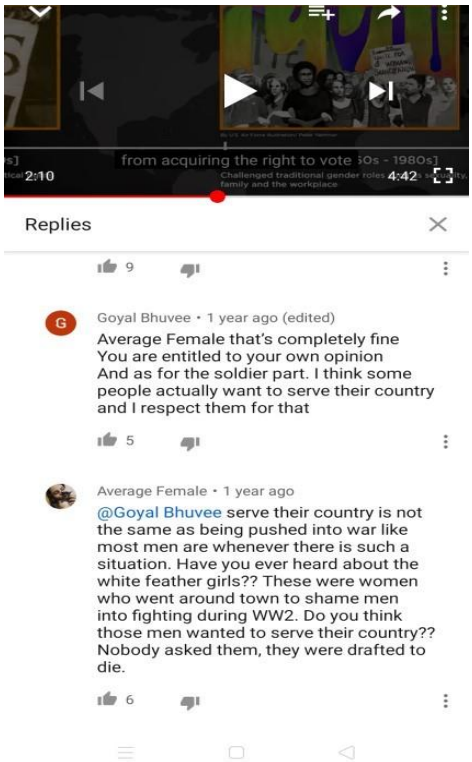


Figure 2: Reply by Goyal Bhuvee and reply by Average Female

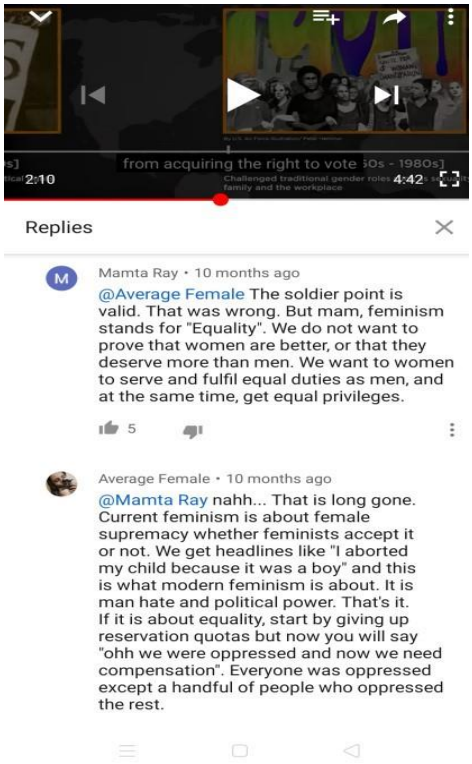


Figure 3: Comment by Mamta Ray and reply by Average Female

A user with screen name Average Female is seen consistently trying to associate Feminism with disintegration of family as a structure, particularly in the West, and claiming that the movement is harmful for women in the long run. She relates Feminism to the privilege women had during
the Second World War by virtue of their gender while men were forced to go to the battle field. Though Goyal Bhuree and Mamta Ray try to draw home the point that Feminism is about equality, Average Female is seen claiming that current Feminism is about "female supremacy". She extends her argument to reservation on grounds of gender (refer to fig. 1, fig. 2 and fig. 3).

This instance of negative feedback and counter comments by neutral entities is particularly interesting as the nature of the feedback is complex and on an overt level the negative feedback can seem quite convincing to anyone with insufficient knowledge about core principles of Feminism and average

media literacy. Average female has structured her arguments in such a way that the urban, semi-urban educated audience particularly new viewers of Vitamin Stree could fall a prey to the subtle stereotypical viewpoints the user tries to advocate.

Applying Post Feminism and Feminist Critical Discourse analysis to the comment sections of the primary texts reveal that Kubra Sait's video has elicited positive comments that consider her to be representative voice that gives expression to what most women desire, essentially to live in a free and safe society. Cathartic, affective reactions describing bodily sensations such as goosebumps as well as homogenizing and universalising tendencies such as 'every girl', 'any woman' and resonance with the harassment anxiety in the video can be observed. Some comments compliment the beauty of the performer, while simultaneously policing her by providing suggestions about attire as in 'I think you should not wear dirty kind of dresses' typically exhibiting post-feminist symptoms. Comments that do an oppositional reading of Sait's video resort to typical stereotypes and interpret the performer's demands as crying, whining and feminine weakness. They bank upon women as whimsical, enigmatic entities. Some comments expect the performer to take matters in her own hands and retort 'who has stopped you?', 'You are a feminist…you can do what you want'.

Priya Malik's "Right to Pleasure" has received severe backlash in the comments as the poem sets out to addressing a more disturbing issue that has been looked at from lens of stigma, that is, women's pleasure. Of several ways of countering the performer, some include discrediting her expression as attention seeking trope, men assuming the role of victims and complaining about effort and money that is invested in relationships with women and visualizing consent as a hurdle and 'unnatural'. Like the previous comment section, stereotypes of reducing women to binary, that is, chaste woman versus fallen woman, and celebration of pleasure within the construct of marriage have been used for moral policing. Resacralisation of the woman's body, insults targeting the performer's parents and ridiculing the performer's accent and education can be observed. Patterns of appreciation include the pedagogical value of the poem, romanticizing the performer's articulation abilities, expression of allyship and individualized self-care where, in the post-feminist sense, caring for herself becomes a woman's sole responsibility and has almost no connection with social factors.

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Like Kubra Sait, Priya Malik is complimented for her voice, articulation and universalized for representing voice of all women. The compliments also show benevolent sexism in lines such as women are the ones who are more gifted than men!".

The comments on Jhansi's "Princesses Don't Make Chai, Do They?" read the performance as a testimony as well as an exaggeration. The performer's credibility and credentials are questioned when she exposes the physical and emotional labour that women invest in a patriarchal institution like marriage. Comments use society as a grammatical agent to semantically absolve men and families of assuming responsibility towards sharing domestic labour and realizing dreams of women. Concerns against patriarchal system are taken as a comment on Indian traditional culture and the performance is read as having agenda to tarnish the national image. There is also discussion on endogamy, caste, religion, parental approval in connection to woman's agency to choose a partner. Housework is read as a marker of respect.

A key finding of this study is that characteristics of YouTube such as hypersociality, hypermediacy, individualization, mass contextualization and YouTube vortexes provide fecund ground for post-feminist patterns. Overtly, presence of feminist content on the internet seems a temporary relief, examining audience feedback through mechanisms such as likes and comment sections reveals that woman's agency is entangled with self-scrutiny serving larger neoliberal and post post-feminist logic.

CONCLUSION

In conclusion, YouTube as a social media platform is at the crossroads of convergence culture as well as divergence culture. As YouTube faces the massive challenge of AI algorithms originally meant to monitor the nature of content today threaten to entrap hyper engaged users into YouTube Vortexes and negative feedback loops. Positive co-creative culture supplying feminist content to reduce the exposure to patriarchal, misogynistic and sexist content may not always bring about desired change in the audience mindset. Critical Discourse analysis of the comment sections reveals that YouTube as a social media platform has added to post feminist ambivalence where principles of feminism are subsumed under the pressure of consumerist and neoliberal forces.

Conflict of interest

The author declares that there is no known conflict of interest.

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Konknni Nattok ani Tiatranim Bailanchem Bondd- Pundalik Naik hanchea Nattkam ani William Fernandes hanchea Tiatram sondorbant

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Saranx: *Nattok ani Tiatr somazacho arso oxem mhonnttat. Somazant jem kitem ghoddta tea vixoyank dhorun Nattok ani Tiatr machier sador zata. Shennoi Goybaban boroil'lem "Mogachem logn" hem rupantorit nattok ani Lucasino Ribeiro baban boroil'lo "Italian Bhurgo" ho tiatr sador zalo tedna thaun Nattok ani Tiatr aiz meren machiechim sopnnam choddot asat. Survatechea kallant Nattkanim ani Tiatranim bailanchi bhumika dadlech kortale. Punn kall gelo toso bailanim Nattok ani tiatr machier pavl dovorlem. Aiz nattkant ani tiatrant bail veg-veglli bhumika korta ti machier dista. Kednaim ti bhurgeanchi mogall avoi mhunnon, gunnest sun mhunnon, bori dhuv mhunnon, xegunni ghorkarn mhunnon, boreak ani vaittak pavpi xezarn mhunnon ani kednai tujer upatt mog korpi mogika mhunnon nattkanim ani tiatranim tichim veg-vegllim rupam dixtti poddtat. Bailechem anik ek rup Nattkanim ani Tiatranim dixtti poddta tem mhonnllear- bail dukh ani on'nyai sonspi. Ghovachea ghorant sasumaichea hatantlean sonspi, bebdea ghova koddlean sonspi, vanzddi mhunnon ghovachea ghorant sonspi, aplea mogeache ot'tyachar sonspi, dhotik lagon mar sonspi- punn ek zap kaddpi nhoi, moneachich sounsar choloupi- oxich tika choddxea nattkanim ani tiatranim prekxokam mukhar haddlea. Dekhun bailanim kel'lem bondd, on'nyayacher avaz uttoita tosli bail choddxi nattkanim ani tiatranim podd'ddea pondak dhampun urlea. Nattok ani tiatr hea edea vhoddlea sahityachea sagorant bailanim kel'lem bondd ho vixoi kaim thembeam sarkoch asa, dekhun kaim mezkeach nattkanim ani tiatranim ho vixoi hatall'lolo dista. Hoch vixoi Pundalik Naik hanchea nattkam ani William Fernandes hanchea Tiatram sondorbant hea lekhant hanvem manddla.*

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Survat

Zaitea nattkanim ani tiatranim adarsh bail mhonnllear sogllem sonsun ghevpi, on'nyai sonspi ani nimanne aplea zulum korpeank maf korpi- Ti bondd korpi nhoi, ti avaz uttoupi nhoi, ti on'nyaya add loddpi nhoi, ti thapttak thapott marpi nhoi- ti svotak kitem vaitt ani kitem borem tem apunn tharaunk xokonam. Tiche khatir sogllem choddxe dadlech tharaitat. Nattkanim ani tiatranim ti sonspi, avaz mat uttoinastanam- henvui nattkam ani tiatr borovpi choddxe dadlech tharaitat. Ani apleacher zatolea zuluma add avaz kaddunk tankam sondi dinastanach, Nattkachea vo Tiatrachea xevottak konn tori yevun fokt tujer kel'lea ot'teacharam khatir 'I am sorry' mhunnonuch nattkacho ani tiatracho podd'ddo denvta ani tanchem avaz uttoupachem boll podd'ddea fattlean lipun veta. Kaim mezkeach nattkanim ani tiatranim bailek bondd korta ti dakhoilea. Hench Pundalik Naik hanchea nattkam ani William Fernandes hanchea tiatram sondorbant hea propotrant hanvem manddlam. Tancheach Nattkachim ani tiatrachim udarnnam diun amchea nattkanim ani tiatranim bailek bollixtt,

apleacher zatolea on'nyayacher apunn zaun zhuzpi oxi dakhoupak zata hem hanv spoxtt kortam.

Nattkanim ani Tiatranim bailanchem bondd he vixoi

Kaim bottar mezunk zatat tea Nattkanim ani Tiatranim on'nyayak protikar korpi ani aple hok'kh dakhoupi bailank sador keleant. Him patram dur'upyog korpi ghovank avhan ditat, on'nyayi vagnnuk nhoikartat ani bhedbhavachea add uloitat. Paramparik moun duk'khi monxabhaxen bonddkhor bail zulum hem aplem noxib mandpak nhoikar dita. Oxim bonddachim rupam veg-vegllim asum yetat. Kaim bailo apleak vaitt vagnnuk divpi kuttumbantlea vangddeank tondd ditat. Zalear kaim bailam xikxonn ani rozgara vorvim arthik svotontr sodtat. Kaim bailam on'nyaya add avaz uttoitat ani bailanchea hok'kham vixim ani soxoktikornnam vixim bodolpi vrut'ti suchoitat. Tor kaim nattkanim ani tiatranim bailanchem bondd dislem torui tem titlem khor bondd nhoi.

Nattkanim Bailanchem Bondd:

Konknni rongmachier dorjedar nattkanchem lekhan korpeam modlea nattokkaram modle jyextt, utkruxtt ani namneche nattakar mhonllear Pundalik Naik, Jayanti Naik, Prakash Vazrikar ani adi. Somaz, bhas, kuttumb, poryavoronn, somazik ekchar oxea sabar vixoyancher tannim ani heranim nattkam boroileant. Hea tigaimchoi ul'lekh korpa fattlem karann mhonnllear, tanchea kaim nattkanim bailanchem bondd disun yeta. Jayanti Naik hichea ***"Kallmaya"*** nattkant matru-sot'ta ji kallam adim choltali tachem chitronn kelam. Prakash Vazrikar hanchea ***"Homkonn"*** ani ***"Bhuim mhoji bangarachi"*** hea nattkanim bailancho bondd disun yeta. Punn hea propotrant fokt Pundalik babachea ***"Dixttdoulot"***, ani ***"Kotha Osturi"***, hea nattkancher hanvem obheas kela.

.

"Dixttdoulot"

Hem nattok Pundalik Narayan Naik hannem boroilam. Tantuntlem cheddum patr "Netra" Devdat ani Devika hanchi lognachea voyachi choli. Netrachi dixtt lagta hi khobor ghorant toxench ak'khea ganvank asta. Netra ghorantlem bhair sorun porot ghorant yeta mhonnllear Netrachi dixtt laglea hacheo kagalli gheun lok tachea bapaik sangunk yetat. Tachi soirik adim heach karannak lagun moddil'li. Netra bhair sorop mhunnllear xezarim bhiyetat. Dekhik- Netrachi dixtt lagun ganvant Mosiger zalolem padduk morta. Tedna xezari Narmada taka ul'lekun oxem mhonntta- "*zaum melem mu. Mhaka he cholyechim lokxonnam dhodd lagona".*

Dixtt lagun konnachea ghoravelo dudi tuttun sokla poddta, taka pollounk ayil'lea novreak tem boro 'shirt' ghatla mhonnun sangta tednach tachea hatantli chav shirtt-acher poddta. Pollounk ayil'lea novrea hujir Avoi Netrak solun kaddta-

Devika- paddpoddilea tuka sangil'lem mugo chodd uloum naka mhonnun. Poddil'lo dant koxem poc'ch korun uloilem koxem?... Tonddan fals. Nodor lagta mhonnttat ti gozal fott nhoi. Xezari Narayan Bud'dhesak Netra kodden logn zainaka mhunn xiddkaita. *Narayan-ayush bor ankvar rav punn oslem khodd golleant bandun gheum naka.* Itlem astanai Bud'dhesh Netra lagim kiteak logn zavunk toyar zata tem nattkant fuddem bhes borem manddlam.

Logn zatoch Bud'dhesh ticho ghov Netrache dixtticho vaitt upyog korta ani duddu zoddta. Dekhik- Moidan bandunk sodtale tea zageavelem khoddop manayakodden futto naxil'lem, tednam Bud'dhesh Netrak gheun pasoyek mhonn veta ani tem khoddop dakhoita. Netrachi nodor tea khoddpacher poddta ani tem mhonntta- "*oslem sullsullit khoddop hanvem kednach pollounk na, itlem sundor".* Dusrea disach manayakodden tem Khoddop futt'ta. Netrache dixttik lagun tem khoddop futtlam, ani apnnem

tem kam kelam mhonn Bud'dhesh tea monxakodden Ekunn'challis hozar geta.
Aplea dhakttea bhavan vhodd bonglo bandla mhonn sangpak Zollve yeta ani to bonglo noxtt kelear apunn tuka ek lakh ditlo mhonn formaita. Bud'dhesh Netrak gheun tea bonglea vatten pasoyek veta. Netrak Bud'dhesh to bonglo dakhoita ani tea bongleak polloun Netra oxem udgarta- *"Avois! Kedna tori sopnant polloilolem ghor dhortorecher denvlam koxem dista".* Dusrea disach tea bongleak uzo pettun gobor zalo hi khobor mellta. Bud'dheshak lagun hem zalam dekhun Zollve taka ek lakh dita. Hem vaitt korpak Bud'dhesh Netrachi dixtt vaporta ani doulot komaita.
Xevttim aplo ghov Bud'dhesh apli dixtt, doulot komoupak vaporta hem Netrak somzota. He gozalicho Netra khor nixed korta. Aplea ghovak sangta- *"Mhojo kiskutt visvas na tujer…Vikallea sorpaborobor ravum yeta, tuje borobor nhoi…ani ekuch sangun dovortam, mhojea moddeak legit affuddcho na…ghov nhoi dusman tum mhojo…Logn nhoi to ek vevhar axil'lo"*- Ho Netran aplea ghova add kel'lo bondd.

Aplea bapaik Netra mhonntta- *"Baba tumcho zanvoi sado monis nhoi. Hat paim haloinastanam aplea payamkodden duddvancheo raxi rokovpachem tontr tannem sodun kaddlam...Bud'dheshan mhoje nodrecho upeg korun ghetlo. Mhoje dixtticho vapor korun koddop foddlem, bonglo laslo".* Bailek duddu komoupachem ek tontr vo sadon koxem vaporlam hem Pundalik Naik hea nattkant manddta.

Netra- Aizver zaitea dadleanim aplea bailancho goirvapor kela. Konnem bailek ghorant vavraddi kelea, sounsar choloila, konnem bailek gol'lear bosoilea, dhondo kela. Konnem bailek baddyak ghatlea ani poixe keleat. Sogllim unnak kama. Punn tunvem tuje bailecho kelolo vapor heramporosui unnak asa... Kitem tuji tokli". Netran kel'lea bondda borobor tacho xinn hea utranim vyokt zata.

Ani Netra xevttak oxem udgarta- *"Zannim lokank nagoun bilddingam ubarleant teo zomnniborvonn kortolem-mhoji dixtt laun. Zannim dusreank pillun voibhov punzailam, tem lasun gobor kortolem- mhoji dixtt laun".* Hea nattkant Netran aplea ghova add kel'lem bondd dista.

"Katha Osturi"
Hem nattok Pundalik Narayan Naik hannem boroilam. Hea nattkant bailanchea jivitak lagu zatat tosleo kotha veg-vegllea prosonganchea adaran manddleat. Vittala-bail hika ganvant ghovachea nanvak lagun vollkhotat. Tichem khorem nanv mat lipun urlam ani Vitall hem ghovachem nanv bailek zoddlam ani ti Vittalabail zalea. Ghorant mixer, gas asun legit ti lakddam ghalun chulik uzo pettoita ani mirem fatricher vantta. Kiteak ghorant axil'lea dadleank gas-ir randil'lem ani mixer-ar vanttil'lem ruchonam. Ghorant tichea manva borobor anik don bapul manv asat. Tankam tigankui tin torechem jevonn, tigaimchoi jevnnacho vell vegllo dekhun Vittalabail dor dis kamant gul'l zal'li dista. Bailek fokot ghorant kam korpachem sadon kelam hem hea prosongant manddlam.

Anik eka prosongant don bailam modem zal'lea sonvadant bailank unnak lekpi vyaky'prachar ani mhonni somazant golltat hacho ul'lekh kela – *"bailechem xanneponn chulikodden, bailo bailancheo dusman".* Tea prosongantlim bail patram oxim udgartat: *Pratibha-bail mhonnllear payanchi vhann.*
Pratima- Oxem mhonnpeache pole vhannanim foddpak zai. Oxem boroun dovortoleanche hat moddpak zai, oxem mantat tanchi kat solpak zai.

TV'cher Khobro- oso ek prosong hea nattkant dakhoila. Bailecheach

tonddantlean TV'cher oxeo khobro sangleat:
Hunddeakhatir bailek zollun marli. Logn zavpak virod korpi cholyechea tonddacher acid. Masteran vidyarthinicho vinoibong kelo. Cholyecher bolatkar korun jivi marli.
Dor 54 minttanim ek bolatkar, 26 minttanim ek vinoibong…
Uprant oxeo Khobro melltat- *bailanim ekttaim yeun soreachem dukan bond kelem* (Bailanim soro piyetolea ghovam add kel'lem bondd), *Lognachea mattvant eke cholyen amontronn nastana yeun fotting novreacher ek thapott fuloilem* (Mogiken ghatki novrea add kel'lem bondd), *Ghovak marun bazun khalo* (Sonsunk zainam titlem dukh ditolea ghova add kel'lem bondd). Bailank piddapidd ditat, on'nyai anik sonsunk zaina zaun on'nyayacher bail monis sudd geta. Bail monxen apleacher zatolea on'nyayacher avaz uttovpak zai hacho orth osoch zata.
Hea khobrancho konnacherui vaitt porinnam zaun konnem apnnalea ghovacher hat ghalcho nhoi oxem khobro sompoitanam suchovnni dilea.

Anik eka oxeach prosongant logn zal'li bail aplem nanv pasun vogddaun bosta hacho ul'lekh kela:
Pratima- Logn mhonnllear tyag, fokt bailen korpacho. Logn zalem ghor bodol'lem, ganv bodol'lo, nokri, kam-dhondo bodol'lo, nanv bodol'lem-fokt bailechem. Logna poilim khoim bhonvpak zata, logna uprant ghov mhonntta apleak horkot na, magir horkot konnachi? Manvachi ani Maichi. Logn zal'le bailek ghovachea ghorant Manv ani ghovachi Maim choloita.

Vostunchem ani zonavoranchem divop ghevop zata. Vostunk mon na, zonavoranchem kitem? Bailankui oxinch ditat. Dadleanim bailek divpachi vost lekhlea. Udaronn: *Pratibha- Karann kitem korpachem tem bailanim, kitem sonspachem tem bailanim. Bailank bhavna nastat. Karann teo danacheo vosti. (Zhuz zatalem tednam Raza apleacher akromonn kelolea Razak apli dhuv dhan kortalo. Rinn farik korunk zainam zatoch bapui aple Cholyek savkarak ditalo. poixeache axek lagun zantteakodden logn korun divop, bail divun rinn pavonk zata)* Hea prosongant dhavak layil'li Droupadi oxi ul'las soddta-
Droupadi- Zo Yudis'ttir haril'lo ani Kavrovancho das zal'lo, taka mhaka dhavak lavpacho odhikar koso favo zata? Ani soglleant mhotvacho proxnn-ponnank lavpak bailmonis hi kitem nirjiv vost? Tika mon-kalliz, bhav-bhavna kitem astat kai na? Dekhun hea nattkantlean Pundalik bab bailanim apleacher zatolea on'nyayancher avaz uttouncho oxem avhan korta. (Droupadin bondd kelo) Tuka tujea ghorcheanim dhavak lailea mhunnon tondd bond korun ravpachem nhoi osoch sondex hea nattkantlean mellta.

Mirvonnukent eka dadleachem moddem asa ani eke bailechem. Punn na, dadlo mela punn bail jiti asa. 30 te 35 vorsanchi. Ti bail bobo huyeli marta punn vad'dheanchea avazan ticho bovall konnakuch aikunk yena. Mirvonnuk sornnakodden pavta. Bailecho akant vaddta. Dadleachem moddem hulpota. Bail pollun vochunk sodta punn xok'ky na. Ani char zann tichi pottli ubartat ani tika sornnacher uddoitat. Tea sornnant bailuch nhoi, punn bailechim sopnam, tiche odhikar ani hok'kh lasun vetat hem Pundalik Naik hea nattkant dakhoita.

Anik eka prosongant bailek Korttant ubi kelea ani ti apleacher ghatil'lea aropancher nixed korta. Vokil mhonntta- *Ghorant undir aslear pasun to marpak tuka bhav lagta vo ghov lagta.* Ti bail mhonnta- *Ambedkaran rochil'lea Sonvidanant bailmonxek dadleam borobor soman odhikar asat.* 5 hozar vorsam cholot ayil'li porompora. Bailek dadleam borobor soman kednach mandli

na. 5 vorsam pinzreant bond korun dovril'lea kirak tumi sangtat- *"polloi atam pinzro ugto kela. Tum svotontr asa. Zaumchem na tea kirachean uddunk"*. Bailek oxich pizreant vorsanchim vorsam bond korun dovorlea.
Ostorek on'nyayacher avaz uttounk svotontr zai toxench sounsarant zogunk dadleacho sangatui zai hem nattkachea xevottak bail vinchun kaddta.

Tiatranim Bailanchem Bondd:
Tiatr mollar zaitea tiatristanim veg-vegllea vixoyancher tiatr boroile. Tiatranim legit Bailanchem bondd khub komi promannant ailam. Wilmix Mazarello, William Fernandes, Menino Araujo, Tomazin Cardozo adi, hanchea tiatranim thodde promannat Bailanim on'nyayacher avaz uttoila hem nodrek poddta. Wilmix Mazarello hachea ***"Mhojea jivitachi kanni"*** hea tiatrant Luciana hea patrachi khobor sanglea. Luciana lhan pirayer thaun koxtt kaddtta, bhurgem zatoch logn zal'lo ghov sompta, portun kazar zatoch ghov tras dita, portun bapaichea ghora yeta, Mumbai kamak veta ani uprant pordesant ravun aple dhuve ani ghorcheam khatir zorun-morun vaur korta- he bail monxechem chitronn hea tiatrant ailam. Menino Mario Arauzo hachea ***"Baddeacho Kusvo"*** hea tiatrant aplo kusvo baddeak dil'lea eke bailechem chitronn kelam. Punn hea propotrant fokt William babachea ***"Thapttak thapott"***, ***"Map bhoron vontlem"*** ani ***"Kudd'ddo nyay"*** hea tiatrancher hanvem obheas kela.
"Thapttak Thapott" ho tiatr William Fernandes hannem boroila. Meera-cho ghorkar ek nanvosto potrakar, Bengluru potrak kam' korta. To sodpus korta astanam kaim Hospittolam bekaidexir vokdancho dhondo kortat ani kitlexe duenti moronk pavtat. Tachea sompadokak hem chapunk naka asta. Heach pasot Sunil apli sirvis soddun Gõyam aplea ghora portota.
Meera tachi ghorkan ek ghor-sonvsari ostori. Sunil Gõyant yeun aplo chapkano ugoddta ani potr bhair kaddtta. To serkaracher kitem-kitem boroita mhonn tacho khun kortat. Aplem ghorkarachea mornnachem dukh Meera tiatrantlea eka Kant-antlean ugtaita:
Ghor sounsar korunk eke ostorek, goroz asta ghorkarachi
Ghorkara vinnem ostorechem jivit, khol baim zata dukhachi
Ghorkar astanam sangatan, mauta kensank mall sobit fulanchi
Ghorkar sangat soddun vetoch, kallokhi vatt fuddarachi.

Ch

Ghorkar, divo eka gharacho
Ghorkar sangat ghorkarnicho
Ghorkar bapui aplea bhurgeancho
Ghorkar srungar eke potinicho

Punn Meera aplea ghorkara fattlean sogllem soddun dina. Meera ek dhaddxi ostori, aplea ghorkaran suru kelolem potr bond poddonk dina punn svota apunn tem choiloita. Ticho sasupai zo svotontr soinik asta to tika adar dita. Zaiteo add-melli ani tras tika bhogche poddtat. Punn Meera kalljidarponnim potracho karbar choloita. Akhrek aplea sasupaik pasun khuni mhonn xid'dh korta. Dekhun hea tiatrantlem Meera on'nyayacher avaz uttoita tosli bail monis.

"Map Bhoron Votlem"
Ho tiatr William Fernandes hannem boroila. Arjun ek Dy. SP asta. Tachi avoi Gangu Ayi. Arjunank kaim rajkarnneachea aropank lagon rajyacho mukhel montri nilombit korta ani tacher arop ghalun bonddkonnint ghalta. Tachi avoi Gangu taka tenko dita. Tanchem ghor asa tem bulldozer ghalun moddtat. Gangu, Arjunank gheun tachea ixtt Robertaxim ravonk yeta. Robert ek Sorv Unch Nyayalayacho vokil asta. To taka modot korta. Mukhel Montri soglle apleacher ghatlole arop fattim ghe mhonn sangta, nam zalear tachea jivak dhoko astolo mhonn kolloita. Gangu taka avhan dita. Mukhel montriache virudh ti

vechnnukek bosta ani jikhta. Arjun-ak nyayalai kosloch arop nam mhonn soddunk porvangi dita. Eke avoin aplea puta khatir ani somazant choltolea broxttachara add kel'lo bondd hea tiatrant dista. Hea tiatrantli Gangu on'nyayacher avaz uttoita tosli ostori. Hea tiatracho nimanno sondex ticheach tonddantlean mellta. *Gangu- Mhojea putak Arjunank hanv sodanch ekuch sangot ailam. Sotan chol ani sotak fuddem korunk kednach bhienakai. Ani mhozo put sodanch hench pallit aila. Mhojea procharant hanvem tornatteank ani dor eka nagrikak hoch ulo marla. Broxttachar, hotyachar ani zulumxahi eke vatten ani sot, promannikponn dusre vatten, hanche bhitor hi loddai zali. Ani akhrek sot zoitivont zalem. Mhojea amdarachea vavrant hanv hench korunk vaurtolim ani ek novo somaz bandunk proytn kortolim. Aiz amchea nagrikanim dakhoun dilem kim tim sota khatir zhuzonk bhiyenant ani hea fuddem broxtt monis unchlea podar nakat mhonnun, kiteak tanchem Map Bhoron Votlem.*

"Kudd'ddo Nyay"

Ho tiatr William Fernandes hannem boroila. Juiz Mona sodanch sot asa thoinch nyay dita. Punn kaim dhondekar ticher ani tichea ghorabeacher akromonn kortat. Punn ti koxich bhiyenam. Ticho poti Joncy, ek boro potrkar punn soro piyeta ani tacho kosloch adar tika asonam. Tika dogam bhurgim. Clive, tornatto iskolak veta ani Joslyn kolejik asta. Dhondekar apleak sojea dilea mhonn Juiz Monachea ghorabeacher vaitt prosong haddun sogllem nisontonn korunk mukhar sorta. Punn Mona he soglle addkollink fuddo korta. Tichea ghorantlim monxam tika sangat dinant. Aplo ghorabo koso ascho tem Mona eka Kant-antlean udgarta:

Ek ghor fokot vonttichem asonam
Jiyeunk, fokot jevonn ani udok pavonam
Ekcharan vontti bandunk zai, huskean
tacher padding ghalunk zai
Ghorabo vaddta, sogllim mogan
jiyetanam.

Osoch ghorabo amcho ascho, him
mhojim khaltim prarthonam
Fokot sukh amchea ghorabeant magtam,
ani kainch hanv magonam.

Joslynacho novro, eka dhondekaracho put, tika mog korta mhonn fottoita ani taka gorbest korta. Joslynachim vaitt chitram Monak dhaddta. Punn Mona aple dhuvek sangat dita:

Salu: Madam, haka matxem samball. Tem jiv diunk proitn kori. Hanvem somzaun haddlam taka. (Joslyn yeta ani Monachea vengent xevttota)

Mona : Kainch bhiyenakai bai. Hanvem tim chitram polleleant. Mhaka tim mobailar dhaddleant.

Joslyn : Mama, I'm pregnant. Hanv gorbest asa. (Mona porot taka vengent geta)

Mona, oslea vellar aple dhuvek apnnaita ani gorbpatt korinam zaunk budh dita. Clive drugs-ak bhulta. Punn Mona takai salvar korta. Xevottak ak'khea ghorabeacho ekvott korun tea dhondekarak boro dhoddo xikoita. Aplea kuttumbacher yetolea sonkoxttocher ani somazant zatolea on'nyayacher zhuzta tosli dhaddxi ostori mhunn hea tiatrant Monachem chitronn kelam.

Nixkorx:
Zaitea nattkanchem ani tiatranchem khaxeleponn mhonnllear somazik bodol chodd korun bail kruti poros dadleanchea rupantora vorvim zata. Bailanchem dukh polloilea uprant xevottak ghov, bapui va her apleo chuko vollkhun ghetat ani apli vagnnuk bodolpachem tharaitat. Durupyog korpi ghov soro soddta, tras divpi sasumai mogall zata. Hem

porivortan bailank monich dovorta. Bail patram svota sokriy'ponnan nyay sodche poros heranim bodol zavpachi vatt polloitat oxem dista.

Konknni nattkanim ani tiatranim bailank fokt duk'khache bolli mhunnon chitrit korpa poros fuddem vochunk zai. Bailanchea songorxachem chitronn mhotvachem urlem tori Nattkanim ani tiatranim bailank svota khatir nirnnoi ghevpi mhunnon sador korpak zai. On'nyayak avhanam divpi, durupyogak tondd divpi ani aplo svabhiman dakhoupi bailanchem chitronn korun nattok ani tiatr adhunik kallar fuddem vochunk zai. Bailank fokt on'nyayachi bolli mhunnon nhoi, tor svotachem noxib ghoddovpi sohobhageli mhunnon aichea kallar kothon toyar korpachi goroz asa. Veg-vegllea vixoyancher nattkam ani tiatr rochleat. Punn Bailanim kel'lem bondd hacher chodd promannant nattkam vo tiatr disonant. Pundalik babachea nattkachim ani William babachea kaim tiatrachim udaronnam hanvem dileant. Punn aiz somazant bail monis zaiti fuddem pavlea. Apleacher zatolea ot'tyacharancher ti avaz uttounk xokta ani uttoitai bi. Tor dadle borovpeanim nhoi tor, bailam borovpeanim tor osle vixoi nattkant ani tiatranim hatallunk zai. Tednach tiatranim ani nattkanim ek bollikxt bail ji svotacher on'nyay zalear zhuzta ti dixtti poddtoli. Tich Bonddkhor bail astoli.

CONFLICT OF INTEREST

Hea sanshodhan karya sombondan mhaka kosloch vay'yaktik vo arthik swarth na.

ACKNOWLEDGMENT

Hea sanshodhan karya khatir margdorxonn dilolea soglleancho hanv abhari asam.

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Bio-Based Curcumin-Embedded Chitosan Matrix for Real-Time Colorimetric Detection of Fish Spoilage

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Abstract: *Global food supply chains suffer from massive seafood spoilage due to rapid microbial and enzymatic degradation, creating an urgent need for sustainable, intelligent food packaging (IFP). This study presents the development and evaluation of a 100% bio-based colorimetric freshness indicator film using a surface-patterned (scribed) curcumin-embedded chitosan matrix. Spectrophotometric analysis confirmed that curcumin undergoes a vivid, pH-dependent bathochromic shift from yellow to deep reddish-orange between pH 5 and 10, driven by phenolic deprotonation. The optimized film formulation demonstrated uniform thickness, high moisture integrity, and reliable mechanical flexibility. When applied directly to Indian mackerel (Rastrelliger kanagurta) at ambient temperature (30 °C), the intelligent film successfully monitored volatile basic nitrogen (TVB-N) accumulation qualitatively, transitioning from bright yellow (fresh) to reddish-brown (spoiled) within 5 hours. This visual sensor provides a cost-effective, non-destructive tool for real-time seafood quality monitoring.*

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INTRODUCTION

Food packaging has changed from its original role as a simple barrier keeping contaminants away from food (Biji et al., 2016). The global food industry faces challenges including rising food waste, higher consumer demand for safe food, and growing environmental concerns about plastic packaging (Azeredo, 2009). Around 1.3 billion tons of food is wasted each year including perishable seafood (Gram & Dalgaard, 2002). This highlights the need for new packaging solutions that track quality in real time.

Fish products are highly perishable due to high moisture, neutral pH, and endogenous enzymes (Gram & Dalgaard, 2002). Microbial activity is the main factor causing fish spoilage. Gram-negative bacteria decompose nitrogenous compounds in fish muscle, generating TVB-N (Total Volatile Basic Nitrogen), a combination of ammonia and trimethylamine (TMA) (Gram & Dalgaard, 2002). These alkaline molecules elevate the pH of the fish surface from neutral to alkaline (Kuswandi et al., 2012). Dyes like curcumin undergo a bathochromic shift (a shift of spectral absorption toward longer wavelengths) when pH rises due to the deprotonation of phenolic hydroxyl groups, transitioning from yellow to orange-red (Tonnesen & Karlsen, 1985; Priyadarsini, 2014).

Intelligent food packaging (IFP) combines smart systems with traditional packaging to monitor food quality and shelf life (Biji et al., 2016). Colorimetric food freshness indicators (CFFIs) are colour-changing visual sensors that are simple, cost-effective, and provide easily

understandable information without needing special equipment (Priyadarsini, 2014). They work by changing colour in response to chemical shifts related to food spoilage (Kuswandi et al., 2012). Chitosan, a natural biopolymer derived from the deacetylation of crustacean chitin, is known for its film-forming abilities and biodegradability (Dash et al., 2011). Natural colorants such as curcumin show pH-responsive colour changes that can be applied to monitor food freshness (Yong et al., 2019). This study focuses on creating a curcumin-embedded chitosan biofilm as a pH-sensitive intelligent packaging system for monitoring fish spoilage.

METHODOLOGY

Analyses of Curcumin Functionality

Chitosan (95% purity) and laboratory-grade curcumin were sourced. Curcumin was dissolved in absolute ethanol to make a stock solution (1 mg/mL). A series of ethanol-based dilutions (6.25 to 100 µg/mL) was prepared, and colour progression was observed in daylight conditions (Priyadarsini, 2014). The pH sensitivity of curcumin was investigated by mixing 0.5 mL of curcumin stock with 9.5 mL of solutions adjusted from pH 1 to 14 using standard HCl and NaOH. The absorbance at 400–600 nm was documented using a UV-visible spectrophotometer.

Preparation and Optimization of Chitosan Matrix

The matrix was prepared using the solvent casting technique. Chitosan (3.5 g to 4.0 g) was dissolved in 1% (v/v) aqueous acetic acid under magnetic stirring. Glycerol was added as a plasticizer (0 to 1.0 mL) to enhance flexibility. The solutions were cast onto Petri dishes coated with paraffin wax and dried at room temperature for 48 hours. Four distinct trial compositions (CMT-01 to CMT-04) were evaluated.

Directly adding curcumin into the acidic chitosan formulation caused an immediate dark reaction that masked pH sensitivity; therefore, a surface-patterning (scribing) method was followed. Dried optimal chitosan films were neutralized in dilute NaOH (0.01 N) to eliminate remaining acetic acid, cross-hatched with a sterile scalpel to form microscopic retention grooves, and immersed in the curcumin-ethanol solution (1 mg/mL) for 5 minutes before drying.

Physicochemical Characterization

Film thickness was measured at five random points using a digital vernier caliper (0.001 mm precision). Moisture content and water solubility were determined gravimetrically by drying samples at 105 °C before and after a 24-hour immersion in distilled water. Water holding capacity was evaluated by calculating the weight of water absorbed per gram of dry film after 24 hours. Quantitative color analysis was performed using the CIELAB color space scale (L*, a*, b*), calibrated via a smartphone-based color identification app (ColorGrab) and cross-checked using the standard international formula defined by the Commission Internationale de l'Éclairage (CIE, 2004): $\Delta Eab = \sqrt{[(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]}$.

Application in Fish Spoilage Detection

Fresh Indian mackerel (Rastrelliger kanagurta) was refrigerated at 5 °C, then transferred to a sterile tray at room temperature (30 °C) and allowed to equilibrate for 1 hour, establishing the baseline (zero hour). The pieces (2 cm × 2 cm) of the curcumin-scribed-chitosan film were applied directly to the lateral side of the mackerel skin for 60 seconds at intervals of 0, 1, 2, 3, 4, and 5 hours. High-resolution digital photographs recorded visual transitions against a standardized colorimetric chart. For benchmarking, an accelerated spoilage

test was simultaneously run using commercial wide-range pH indicator paper moistened with 50 µL of distilled water and applied to a separate mackerel specimen for 60 seconds after 5 hours of storage. Indian mackerel was selected because it is one of the most widely consumed, affordable and readily available fish along the Indian west coast and, as an oily pelagic species that spoils rapidly at ambient temperature, it served as a representative model for this proof-of-concept study. The experiment was performed on mackerel specimens (n=3) sampled from the same batch of fresh fish, with each time point recorded in triplicate. The accuracy of the film response was assessed through comparison of film colour with pH paper readings across replicates. The shelf life of the film was not evaluated in this study. Films were prepared fresh and used within 15 days of preparation. Long-term storage stability under different light, humidity and temperature conditions will be examined in future work.

RESULTS AND DISCUSSION

Curcumin Concentration and pH Indicators

Serial dilutions of curcumin confirmed a gradual fading from a deep yellow-orange color at 100 µg/mL to faint yellow at 6.25 µg/mL. Quantitative CIELAB values revealed that lightness (L*) increased from 59.90 to 85.47, while the redness index (a*) dropped from +45.99 to -4.40, indicating complete loss of red components. The largest total color difference (ΔE = 34.18) occurred during the initial dilution step from 100 to 50 µg/mL (Figure 1).

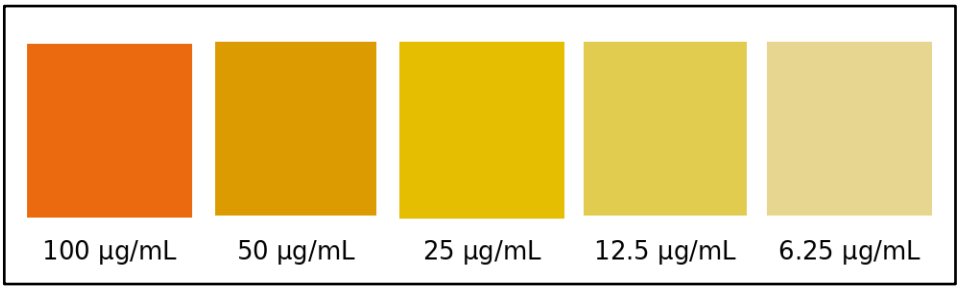


Figure 1. Documented colour correlated with different concentrations of curcumin solutions

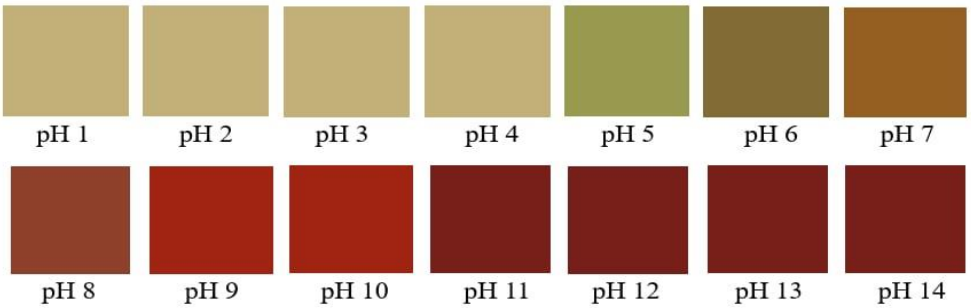


Figure 2. Colour of curcumin solution at different pH constructed through CIELAB data

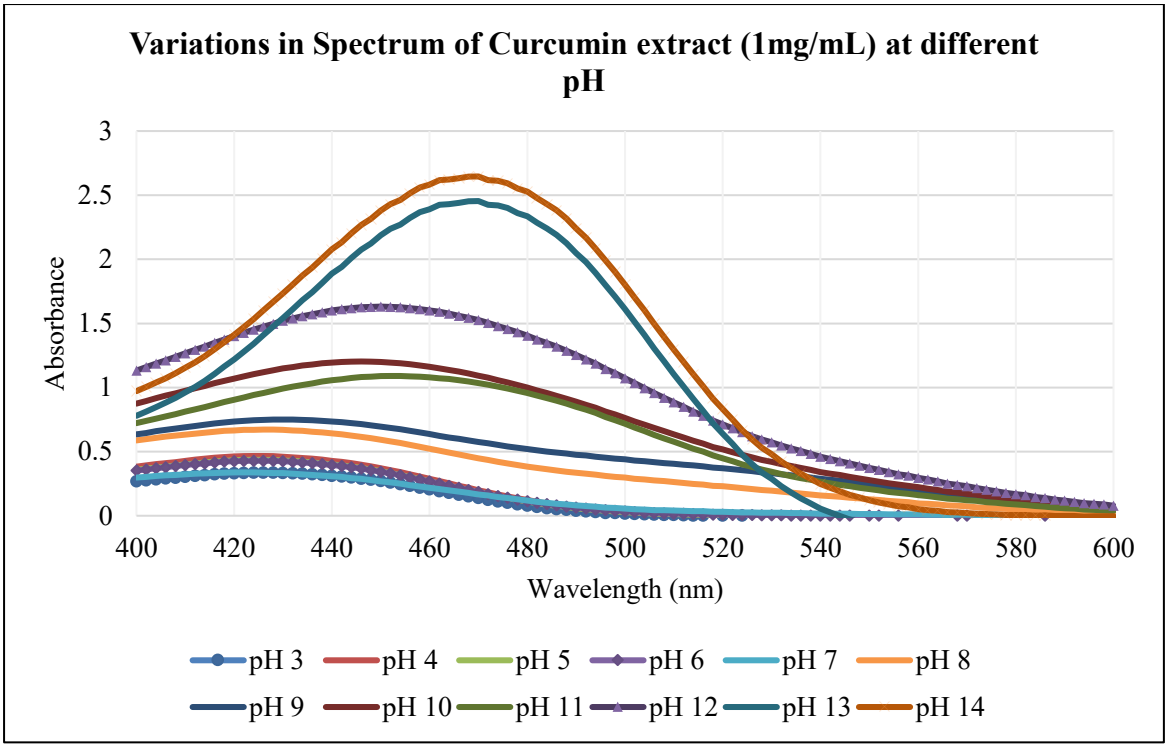


Figure 3. Colour spectrum of the curcumin (1 mg/mL) at varying pH. Visible changes seen in the spectrum after pH 5. Absorption maxima (λmax) lie at approximately 420–470 nm.

Across a pH range of 1 to 14, curcumin solutions exhibited high visual sensitivity (Figure 2). In acidic environments (pH 1–5), the solution remained a stable pale yellow (L*=72.15, a*=-1.65, b*=31.05). Between pH 6 and 7, structural transitions shifted the color to yellowish-brown. In alkaline environments (pH 8–10), deprotonation generated enolate ions, shifting the solution to a vibrant reddish-orange, which deepened to reddish-brown at pH 11–14. The highest consecutive color shift occurred between pH 9 and 10 (ΔE=22.45), confirming a correlatable tracking capability within the exact alkaline range associated with seafood spoilage. Spectrophotometric scans confirmed that the enolate shifts extend the π-electron conjugation, moving the absorption maximum (λmax) from 420 nm up toward longer wavelengths (bathochromic shift) (Figure 3).

3.2 Film Formulation Optimization and Physicochemical Analysis

Four trials were carried out to optimize structural performance. CMT-01 (zero glycerol) failed to solidify. Trial CMT-02 (high moisture, low thickness) proved too soft and structurally weak, whereas trial CMT-04 (1.0 mL glycerol) solidified but resulted in a highly brittle matrix. Trial CMT-03, composed of 3.5 g chitosan, 100 mL of 1% acetic acid, and 0.5 mL glycerol, yielded a uniform, highly flexible, and mechanically stable matrix with ideal lower moisture content, making it the chosen selection for indicator embedding. The physicochemical properties of the four trials are summarised in Figure 5 and their numerical values (thickness,

moisture content, water solubility and water holding capacity) are given in Table 1. The CIELAB values (L*, a*, b*) of the curcumin-embedded film at pH 7–10 (Figure 4d) are given in Table 2.

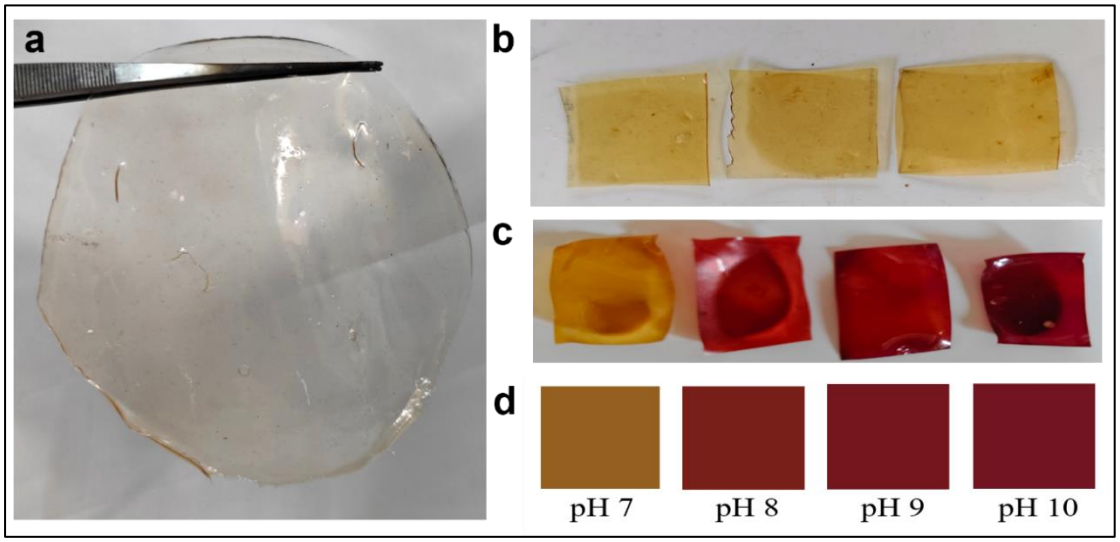


Figure 4. CMT-03 matrix (a) without curcumin, (b) scribed with curcumin, (c) curcumin-embedded film at pH 7, 8, 9 and 10, and (d) the corresponding colour swatches generated from the CIELAB parameters at pH 7–10.

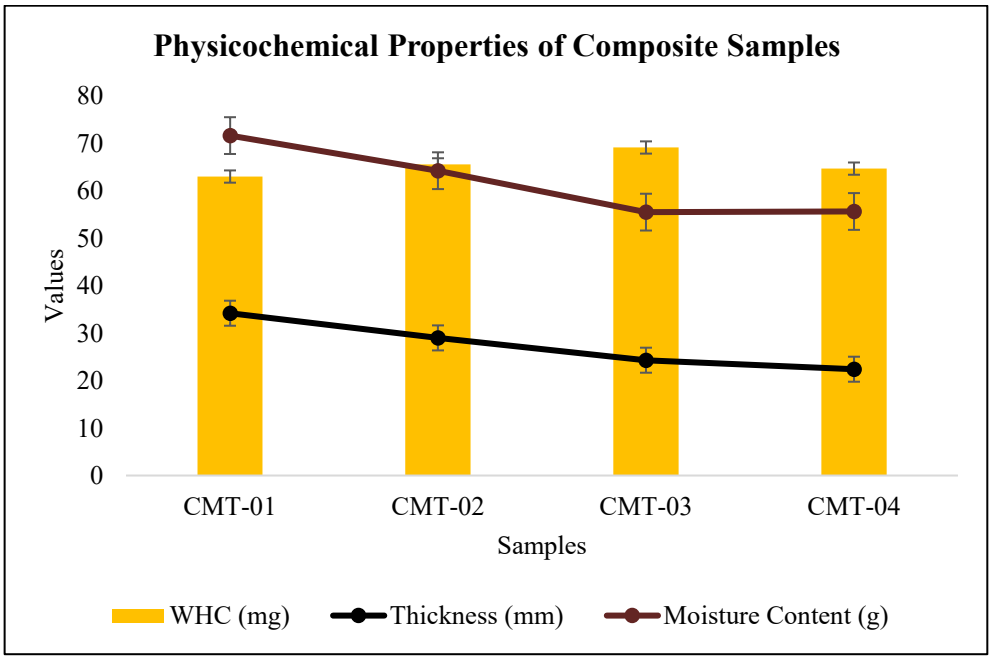


Figure 5. Graph summarising physicochemical properties of the film formulations CMT-01 to CMT-04. CMT-03 was selected for further studies.

Table 1. Physicochemical properties of the chitosan film formulation (CMT-03) (mean ± SD, n = 3)

Formulation	Description	Thickness (mm)	Moisture content (%)	Water solubility (%)	Water holding capacity (%)
SC-A	Chitosan film without curcumin	0.214 ± 0.0144	31.74 ± 2.334	13.47 ± 0.482	63.20 ± 7.803
SC-B	Direct embedded method	0.226 ± 0.0124	32.50 ± 2.209	30.54 ± 10.52	64.66 ± 8.672
SC-C	Cross pattern method	0.218 ± 0.0134	33.15 ± 2.596	15.13 ± 2.95	70.30 ± 4.608

Table 2. CIELAB parameters of the SC-C film at different pH levels compared with pH 1.

pH	ΔL*	Δa*	Δb*	ΔE (vs pH 1)
6	10.38	9.09	7.05	15.49
7	25.55	3.13	3.04	25.92
8	26.96	18.21	11.99	34.68
9	35.06	33.10	2.09	48.26
10	36.50	51.68	10.43	64.13
11-14	45.29	39.73	4.56	60.42

Table 3. CIELAB colour parameters (L*, a*, b*) of control pH paper and pH paper after testing.

pH paper status	ΔL*	Δa*	Δb*	ΔE (vs pH 1)
Control	72.15	65.47	-1.65	16.39
Test	65.47	-5.91	45.40	

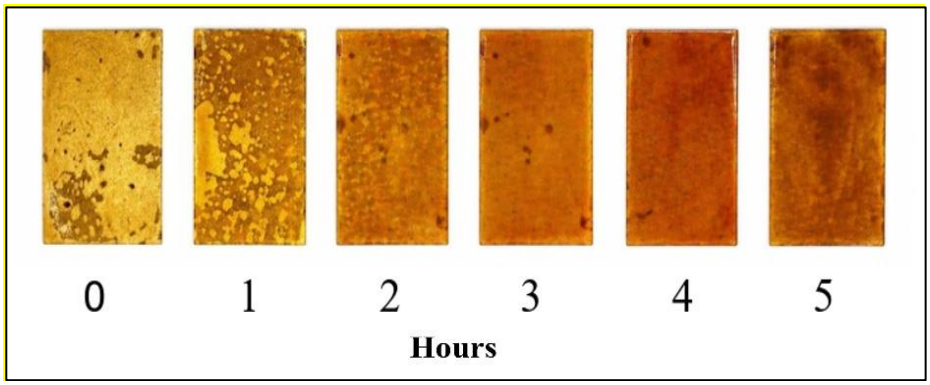


Figure 6. Colour change of curcumin-embedded film (SC-C) at different time periods

Table 4. Qualitative Colorimetric Response of Chitosan-Curcumin Film in Place on Surface of Whole Indian Mackerel (Rastrelliger kanagurta) at various time intervals under ambient temperature conditions (30 °C)

Exposure Time (Hours)	Spoilage Stage Designation	Observed Film Color of VBN Accumulation	Colour	Indication of VBN Accumulation
0	Fresh	Bright yellow		Below Detection Limit / Absent
1	Initial Spoilage	Pale yellow		Trace Detection
2	Early Spoilage	Light orange		Low Accumulation
3	Mid Spoilage	Distinct orange		Moderate Accumulation
4	Advanced Spoilage	Deep orange		High Accumulation
5	Significant Spoilage	Reddish brown		Very High Accumulation

Spoilage Monitoring and Benchmarking

During application on room-temperature-stored mackerel, the optimal Trial CMT-03 scribed film accurately recorded degradation of fish quality over the 5-hour duration (Figure 6). At 0 hours, the film retained its bright yellow coloration, confirming product freshness. As volatile basic nitrogenous compounds accumulated in the fish headspace and skin layer, the film shifted to orange by hour 3, reaching a deep reddish-brown state at hour 5, indicating severe spoilage.

The comparative benchmarking trial using commercial wide-range pH paper on the spoiled fish at 5 hours, yielded a surface pH reading matching the colour chart profile for pH 6–8 (Table 3). This result indicates that the curcumin-chitosan matrix responds to the alkaline shifts generated by volatile basic amines (ammonia and TMA), in qualitative agreement with the chemical indicator, while providing a non-toxic, food-safe, and biopolymer-integrated packaging alternative.

The deep reddish-brown colour of the film at 5 hours (Figure 6) corresponds to the pH 8–10 range established for curcumin solutions in Section 3.1, whereas the pH paper indicated pH 6–8 on the fish surface. This difference is most likely because the two indicators do not report the same quantity. The pH paper was moistened with only 50 µL of distilled water and therefore reads a diluted, buffered surface pH; in addition, wide-range pH paper has coarse resolution (approximately one pH unit per colour step) and is read visually against a chart, so a value near the upper end of the reported range cannot be excluded. In contrast, the film is held in close contact with the skin, where volatile amines (ammonia and TMA) accumulate in the confined space between film and fish and can deprotonate curcumin directly, without requiring a bulk aqueous phase. Moreover, the pH paper was applied to a separate specimen, and the pH–colour relationship discussed was established in solution, so the apparent transition range of curcumin within the solid chitosan matrix may differ.

The film response in this study is semi-quantitative (visual). The study was performed on Indian mackerel only because spoilage patterns and volatile amine profiles differ among fish species, validation on other commonly consumed species (e.g. sardine, pomfret and

kingfish) is needed before general application. TVB-N accumulation was monitored qualitatively through the colour change of the film; quantitative TVB-N determination (by Conway microdiffusion or titration) and its correlation with film colour are a future prospect.

CONCLUSION

This study successfully fabricated a 100% bio-based intelligent colorimetric sensor by physically entrapping curcumin within an optimized chitosan matrix via a surface-scribing technique. Curcumin demonstrated highly perceptible visual shifts ($\Delta E > 15$) across alkaline levels, driven by a bathochromic structural shift during phenolic deprotonation. The optimized matrix (CMT-03) provided excellent mechanical integrity and successfully monitored real-time mackerel spoilage, changing from bright yellow to reddish-brown within 5 hours in response to TVB-N accumulation (assessed qualitatively). This biopolymer matrix showed qualitative agreement with commercial pH paper, offering a food-safe, non-destructive, and sustainable intelligent packaging solution for the seafood industry. Quantitative TVB-N determination, accuracy, shelf life and performance on other fish species remain to be established as future work.

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CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

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