Annual Report

2081/82 (2024/25)

Nepal Agricultural Research Council
National Agricultural Research Institute
National Food Research Centre
Khumaltar, Lalitpur, Nepal
2025

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FOREWORD

Food science plays a vital role in Nepal's agricultural landscape, where the need for equitable, resilient, and sustainable (ERS) food systems has never been more urgent. The National Food Research Centre (NFRC), under the Nepal Agricultural Research Council (NARC), is committed to advancing food science and technology to support food and nutrition security, economic development, and public health nationwide. NFRC's mission aligns with national development goals, pathways, and action tracks for Food Systems Transformation to meet the Sustainable Development Goals (SDGs), specifically SDG 1 (No Poverty), SDG 2 (Zero Hunger), SDG 3 (Good Health and Well-being), SDG 8 (Decent Work and Economic Growth), and SDG 12 (Responsible Consumption and Production). These goals guide NFRC's commitment to ensuring food availability, enhancing nutritional quality, and fostering market access for Nepalese products, especially LMSEs, and well as high-value advanced processed, creating meaningful improvements in the lives of farmers, consumers, and food entrepreneurs.

During the fiscal year 2081/82 (2024/25), NFRC has made considerable progress in researching and implementing practical, cost-effective technologies that address Nepal's food and nutrition security and sustainability challenges. A key focus area has been the introduction of advanced processing and analytical technologies to develop high-value agro-livestock products, reduce post-harvest losses, and enhance NFRC's capacity to deliver internationally valid analytical services, ensuring validated analytical reports. Some of the notable example are: NFRC has developed drying technology for large cardamom, optimized mushroom soup powder, initiated the development of biodegradable plastics from cassava flour, conducted fermentation studies on soybeans, and explored extrusion processing of fermented soyabean, *kinema*¸ a cultural delicacy of Limbu Community of Eastern Nepal, studied the changes in microstructure in cereals during different cooking methods, exploration in the physiochemical, nutritional, milling, and cooking qualities of indigenous landraces of rice, changes in the textual and chemical characteristics of cheese during ageing and optimization of processing of thon, a Newari rice based *jand* and broken rice percentage for better physiochemical and sensorial properties. These innovations provide technologies for processing our resources to develop high-value agro-products for niche markets, thereby exponentially enhancing farmers' incomes and deserved livelihoods, increasing shelf life, preserving nutritional quality, reducing food losses, and providing year-round access, which creates new and diverse income opportunities for processors. Value-added products like large cardamom, mushroom powder, kinema, soybean protein concentrate, kinema-meat pickle, goat cheese, and *thon* meet local nutritional needs, hold potential for national and international markets, boosting Nepal's agricultural economy and agro-based processed products, and food and beverage as a beacon of national identity and cultural heritage.

NFRC's research on ethnic foods, crop and horticultural crop varieties, indigenous and those developed by the NARC deepened our understanding of these essential foods' nutritional composition and functional quality, helping a food-based approach to food and nutritional security and health, targeted breeding, and realizing the potential and inclusive socioeconomic and contextual existence. For instance, high-protein wheat varieties and carbohydrate-dense maize identified through NFRC's research are valuable resources for developing nutrient-rich foods that enhance dietary quality and food-based approaches to nutrition security and improve the population's health, and also an excellent raw material for feed. By focusing on nutrient preservation and fortification, NFRC supports balanced diets and addresses nutritional deficiencies, particularly in rural areas where limited access to diverse food sources can hinder public health outcomes. These research insights inform breeding programs, local food production strategies, and dietary guidelines that enhance food security nationwide. Similarly, determining the proximate and nutritional composition of 4 ethnic foods and 46 ingredients has highlighted their importance in nutrition, such as *gundruk,* which has been found to have the potential to contribute significantly to micronutrient requirements, especially iron and calcium.

In addition, NFRC has prioritized the documentation and standardization of those ethnic foods, ensuring that Nepal's traditional foods are preserved, standardized, and optimized for safety and quality. Ethnic foods such as *Kinema, Khapse, Yomari, Choila, Dhido Set, Thekuwa, Thakali Bhancha Set, Gundruk* (fermented leafy greens), *Kaguno to kheer, and Ghongi* are deeply rooted in cultural heritage and hold potential for market expansion through the development of fine-dining recipes. Through NFRC's efforts, these foods are being reintroduced with standardized protocols, nutritional information that maintain their cultural authenticity while meeting modern food safety standards. This initiative creates opportunities for small-scale producers to market authentic ethnic foods, supporting cultural preservation, tourism, and economic growth.

The Centre's pioneering work in plant-based protein and alternative food products further reflects NFRC's commitment to sustainability. With the rising demand for diverse, plant-based dietary options, NFRC has applied fermentation technologies to develop soybean-based pickle and protein concentrate products. These innovations align with global trends toward healthy, sustainable diets and present a significant opportunity for Nepal to diversify its food production, commercialize agriculture, and provide cheap but high-quality protein. Therefore, plant-based protein products can contribute to food sovereignty by reducing dependency on imported foods and promoting sustainable agriculture.

Despite infrastructure limitations and resource constraints, NFRC's dedicated team of scientists, technicians, and staff has demonstrated resilience and innovation, advancing high-impact research that has garnered both national and international recognition. Our work has been supported by collaborations with provincial governments, academic institutions, industry stakeholders, farmers, entrepreneurs, and international organizations. These partnerships strengthen NFRC's ability to address food security and quality challenges comprehensively, leveraging diverse expertise and resources to maximize impact.

Roman Karki, PhD
Chief
National Food Research Centre
October 2025

ABBREVIATIONS

NARC	National Agricultural Research Council
FRU	Food Research Unit
FRD	Food Research Division
NFRC	National Food Research Centre
NAGRC	National Agriculture Genetic Research Centre
LI-BIRD	Local Initiatives for Biodiversity Research and Development
NCBGC	National Crop Breeding and Genetics Centre
NMRP	National Maize Research Program
AFACI	Asian Food and Agriculture Cooperation Initiative
ARC	Agricultural Research Centre
NFDA	Nepal Forage Development Association
NCARP	National commercial Agriculture Research Program
NAFRC	National Animal Feed Research Centre
NCRP	National Cattle Research Program
DAR	Directorate of Agricultural Research
HRC	Horticulture Research Centre
HCRP	Hill Crops Research Program
NPPRC	National Plant Pathology Research Centre
FRC	Fishery Research Centre
NGRP	National Goat Research Program
DFTQC	Department of Food Technology and Quality Control
GoN	Government of Nepal
Gos	Government Organizations
NGOs	Non-Government Organization
INGOs	International Non-Government Organization
FAO	Food and Agriculture Organization
MoALD	Ministry of Agriculture and Livestock Development
FNCCI	Federation of Nepalese Chambers of Commerce and Industry
NDDB	National Dairy Development Boerd
UNDP	United Nations Development Programme
NDDB	National Dairy Development Board
SDGs	Sustainable Development Goals

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प्रमुख सार संक्षेप

नेपाल कृषि अनुसन्धान परिषद् (ने.कृ.अ.प) अन्तर्गत राष्ट्रिय खाद्य अनुसन्धान केन्द्र (रा.खा.अ.के) ले आर्थिक वर्ष २०८१/८२ (२०२४/२५) मा नेपालको खाद्य सुरक्षा, पोषण र खाद्य तथा पोषण सुरक्षाका लक्ष्यहरूलाई अग्रसर गर्न खाद्य विज्ञान, उत्पदानोप्रांत सम्बन्धित अनुसन्धानमा महत्त्वपूर्ण प्रगति हासिल गरेको छ। यस वर्षका उपलब्धिहरूले केन्द्रले राष्ट्रिय र अन्तर्राष्ट्रिय प्राथमिकताहरू, विशेष गरी कृषि विकास रणनीति (ADS) २०१६ र दिगो विकास लक्ष्यहरू (SDGs), मुख्यतया SDG 1, SDG 2, SDG 3, SDG 8 र SDG 12 लाई सम्बोधन गर्ने दृढ प्रतिबद्धतालाई जनाउँछ। केन्द्रले लक्षित अनुसन्धान, नवीन प्रयोगहरू र अन्तर्राष्ट्रिय दात्री निकायको सहयोग मार्फत खाद्य प्रणालीमा सहनशीलता, आर्थिक विकास र सार्वजनिक स्वास्थ्यका क्षेत्रमा अग्रणी भूमिका निर्वाह गर्दै आएको छ। यस अवधिमा केन्द्रको अनुसन्धान पोर्टफोलियोमा ठूलो अभिवृद्धि भएको थियो, जस अन्तर्गत खाद्य विज्ञान, उत्पदानोप्रांत प्रविधि र पोषण विश्लेषणका विविध क्षेत्रहरूमा १६ सक्रिय परियोजनाहरू समेटिए। केन्द्रले आइएसओ/आईईसी १७०२५:२०१७ मान्यता मापदण्डको प्रतिबद्धता कायम राख्दै, नेपालको खाद्य प्रणालीमा रहेका प्रजाति मूल्याङ्कनदेखि लिएर स्थानीय खाद्यपदार्थको अभिलेखीकरणसम्मको महत्त्वपूर्ण क्रियाकलापहरूलाई सीधा सम्बोधन गरेको थियो।

यस आर्थिक वर्षभरि रा.खा.अ.केका अनुसन्धान र गतिविधिहरूका प्रमुख बुँदाहरू यस प्रकार छन्ः

फ्राम व्यवस्थापन र अनुसन्धान सहयोग परियोजनाका नतिजाहरू

फ्राम व्यवस्थापन र अनुसन्धान सहयोग परियोजनाले नेपालका कृषि जन्य वस्तुहरूको विस्तृत भौतिक, रासायनिक र पोषण विश्लेषण मार्फत पर्याप्त डाटा सिर्जना गरेको छ। छवटा धानका प्रजातिहरूको विश्लेषणले १३.३५% देखि १४.२६% सम्मको पानीस्तर देखाएको छ, जहाँ घैया छोट्टेले सुधारित प्रजातिहरू जस्तै खुमल ११ (०.७३ मिग्रा/१०० ग्राम) को तुलनामा असाधारण रूपमा उच्च फलामको मात्रा (४.० मिग्रा/१०० ग्राम) देखाएको छ। यो भिन्नताले फलाम ग्रहण गर्ने जननिकन प्रक्रियामा रहेको भिन्नतालाई इङ्गित गर्छ र प्रजनन/जैवकिकरण रणनीतिहरूको सम्भावनालाई सङ्केत गर्छ। फलामको मात्राको विपरीत, फस्फरसको मात्राले विपरीत पैटर्न देखाएको छ, जहाँ खुमल १४ मा १०५.८७ मिग्रा/१०० ग्राम र घैया छोट्टेमा ५६.४९ मिग्रा/१०० ग्राम रहेको छ, जसले विभिन्न प्रजातिहरूमा जटिल खनिज वितरण पैटर्नलाई इङ्गित गर्छ।

तीनवटा प्रजातिहरूमा गरिएको मकैको विश्लेषणले ११.९१% देखि १४.९१% सम्म प्रोटीन सामग्रीमा भिन्नता देखाएको छ, जहाँ केडब्ल्यूएम-९२ ले उत्कृष्ट पोषण प्रोफाइल देखाएको छ। १०००-दाना तौल २०१.४५ ग्राम देखि २७५.०२ ग्राम सम्म रहेकोले, यसको पिसाई दक्षता र बजार मूल्यमा महत्त्वपूर्ण असर पर्न सक्ने देखिन्छ। कोदो मिलेटका नमुनाहरू (KLE-१५८ र KLE-१५९) ले उल्लेखनीय रूपमा उच्च जस्ताको मात्रा (५.४६—६.९५ मिग्रा/१०० ग्राम) देखाएका छन्, जसले यी प्रजातिहरूलाई सूक्ष्म पोषक तत्त्वको कमी समाधान गर्ने सम्भावित योगदान कर्ताको रूपमा राख्छ।

दालहरूको विश्लेषणले प्रजातिहरू बीच धेरै नै भिन्नता देखाएको छ, जहाँ चना प्रोटिन सामग्री १८.७९% देखि २३.२४% सम्म रहेको छ, भने मुगी (पन्ता-५) ले तुलनात्मक प्रोटीन स्तर तर भिन्न खनिज प्रोफाइल देखाएको छ। केपीजी-५९ चनामा फलामको मात्रा (६.२३ मिग्रा/१०० ग्राम) मुगीको तुलनामा (३.६३ मिग्रा/१०० ग्राम) लगभग दोब्बर रहेको छ, तथापि फस्फरसको मात्रामा विपरीत प्रवृत्ति देखिएको छ।

अलैंची अनुसन्धान र प्रशोधन

अलैंची परियोजनाले यस मूल्यवान् बालीको प्रशोधन प्रविधिमा ठूलो अभिवृद्धिलाई प्रतिनिधित्व गर्छ। सुकाउने विधिहरू, फ्रिज ड्रायिंग, क्याबिनेट ड्रायिंग र हाइब्रिड सोलर ड्रायिंग, को तुलनात्मक विश्लेषणले फ्रिज ड्रायिंगले सर्वोच्च आवश्यक बास्नादार तेल (२.७१%—५.५८%) लाई कायम राखेको देखाएको छ, भने परम्परागत भट्टी विधिले २.५६%—५.२०% दिएको छ। प्रमुख भोलाटाइल यौगिक, १,८-सिनिओल, नमुनाहरूमा ४७.९३% देखि ७३.५७ क्षेत्रफल % सम्म रहेको छ, जहाँ फ्रिज ड्रायिंग गरिएको भारलाङ्गे प्रजातिमा सर्वोच्च मात्रा रहेको इंकित गरेको छ।

उत्पादन प्रतिशत ७३.५२% (रामसाई, हाइब्रिड सोलार) देखि ८१.०२% (भारलाङ्गे, फ्रिज ड्रायिंग) सम्म रहेकोले, प्रशोधन विधि चयनको आर्थिक प्रभावलाई देखाउँछ। अनुसन्धानले १६ वटा भोलाटाइल यौगिकहरू पहिचान गरेको छ जसले सुगन्धित प्रोफाइलमा योगदान गर्छन्, र सुकाउने तापक्रम र अवधिको आधारमा महत्त्वपूर्ण भिन्नता देखा परेको छ। यी नतिजाहरूले किसानको आम्दानीमा सीधा असर पार्छ, किनभने फ्रिज ड्रायिंग गरिएको अलैंचीले परम्परागत उत्पादनभन्दा २००% बढी मूल्य प्राप्त गर्छ।

च्याउ प्रशोधन र मूल्यपर्वदन प्रविधिहरू

रेस्पोन्स सरफेस मेथोडोलोजी प्रयोग गरेर तयारी खाने च्याउको सूप बनाउने फर्मुलेशनहरूको विकासले ०.९७% देखि २७.१२% सम्म प्रोटिन सामग्री भएका १० वटा फरक उत्पादनहरू सिर्जना गरेको छ। फर्मुलेशन ६, जसमा ५०% च्याउ र ५०% दुध ठोस पदार्थ रहेको छ, ले २७.१२% प्रोटीन, ६.४४ मिग्रा/१०० ग्राम फलाम र ६९६.७२ मिग्रा/१०० ग्राम फस्फरसको साथ उत्कृष्ट पोषण सन्तुलन हासिल गरेको छ। फर्मुलेशनहरूमा पानी (६.०८%—८.५४%) ले पोषण अखण्डता कायम राख्दै भण्डारण क्ष्यमता सुनिश्चित गरेको छ।

च्याउ किम्ची विकासको परीक्षणले ५.७६ दिनमा उत्तम किण्वन हासिल गरेको देखाएको छ, जसले पिएच ३.४१, ४.५१% प्रोटीन सामग्री र ५०.५५ मिग्रा/१०० ग्राम फस्फरस रिटेन्सन दिएको छ। अनुकूलित फर्मुलेशनको लागि संवेदी मूल्याङ्कनले ७.६२५±०.८६ को उच्चतम स्कोर हासिल गरेकोले, उपभोक्ता स्वीकार्यताको उच्च सम्भावनालाई इङ्गित गर्छ।

बायोडिग्रेडेबल प्याकेजिंग विकास

सिमल तरुलको स्टार्चमा आधारित बायोडिग्रेडेबल फिल्म परियोजनाले विभिन्न यान्त्रिक र अवरोधक गुणहरू भएका १३ फर्मुलेशनहरू उत्पादन गरेको छ। फिल्मको मोटाई ०.१५ मिमी देखि ०.६७ मिमी सम्म, पानी वाष्प संचरण दर १८.०१ देखि ४१.९९ ग्राम एम$^{-2}$ दिन$^{-1}$ सम्म र पानी शोषण ८५.८३% देखि २०८.८६% सम्म रहेको छ। ७.७५% ग्लिसरिन भएका फर्मुलेशनहरूले लचिलोता र नमी अवरोधक गुणहरू बीच उत्तम सन्तुलन देखाएका छन्, तथापि व्यावसायिक व्यवहार्यताका लागि थप अनुकूलन आवश्यक देखिन्छ।

भटमास किण्वन र किनेमा अनुसन्धान

२० वटा भटमास प्रजातिहरूको विश्लेषणले १८.७९% देखि २३.२५% सम्म प्रोटीन सामग्री देखाएको छ, जहाँ आइसिसिभी-९७२०७ ले उत्कृष्ट पोषण प्रोफाइल देखाएको छ। किनेमा किण्वन अध्ययनहरूले छ दिने

किण्वनले कुल फिनोलिक सामग्री १७३.१३ देखि ७९३.३६ मिग्रा GAE/१०० ग्राम DM सम्म बढाएको देखाएको छ, भने फ्लेवोनोइड सामग्री २१४.५७ देखि ३६६.२३ मिग्रा QE/१०० ग्राम DM सम्म बढेको छ। एन्टिअक्सिडेन्ट गतिविधिको लागि IC50 मानहरू १५.४७ देखि ४.१८९ मिग्रा/एमएल सम्म सुधरेकोले, नियन्त्रित किण्वन मार्फत जैवगतिविधिमा वृद्धि भएको सङ्केत गर्छ।

चिसो सहने धानको मिलिंग र पोषण संरक्षण अध्ययनहरू

विभिन्न डिग्री (०—१०%) मा पोलिस गरिएको चामलको विस्तृत विश्लेषणले प्रशोधन बढ्दै जाँदा नाटकीय पोषण हानिलाई देखाएको छ। फलामको मात्रा ८३% (१.०३ देखि ०.१७ मिग्रा/१०० ग्राम), फस्फरस ६०% (२२०.९७ देखि ८७.८२ मिग्रा/१०० ग्राम) र क्याल्सियम ३१% (१४.०२ देखि ९.६० मिग्रा/१०० ग्राम) ले घटेको छ। स्क्यानिंग इलेक्ट्रोन माइक्रोस्कोपीले एल्युरोन तहहरूको क्रमिक हटाइलाई पुष्टि गरेको छ, जुन पोषक तत्त्वहरूको ह्राससँग सहसम्बन्ध राख्छ। यी नतिजाहरूले हालको पिसाई अभ्यासहरूलाई चुनौती दिन्छन् र उपभोक्ता रुचि र पोषण संरक्षण बीच सन्तुलन कायम गर्न नीतिगत हस्तक्षेपको आवश्यकतालाई सुझाव दिन्छन्।

परम्परागत मद्य पेय मानकीकरण

विभिन्न स्थानहरूबाट लिइएका परम्परागत किण्वित पेयहरू (थोन, रक्सी, जाँड) को विश्लेषणले ८.६% देखि २२.८% सम्मको अल्कोहल सामग्री देखाएको छ, जहाँ मन्दनदेउपुरको मिलेट नमुनाहरूमा सर्वोच मात्रा रहेको छ । अनुकूलन अध्ययनहरूले बालम्बु मुर्चालाई उत्कृष्ट स्टार्टर कल्चरको रूपमा पहिचान गरेको छ, जसले ५.५२ दिनमा उत्तम किण्वन हासिल गरेको छ। अध्ययनले निर्धारण गरेको छ कि उत्कृष्ट उत्पादनमा गुणस्तरलाई कमजोर नबनाउने गरी ३३.३३% टुक्रिएको चामल प्रयोग गर्न सकिन्छ, जसले प्रशोधकहरूका लागि आर्थिक लाभ दिन्छ।

रैथाने खानाको अभिलेखीकरण र पोषण प्रोफाइलिंग (AFCD+ परियोजना)

एसियन खाद्य संरचना डाटाबेस विस्तार परियोजनाले १६ वटा सामुदायिक खाद्यपदार्थहरू र १०० वटा सामग्रीहरूको विश्लेषण गरेको छ, जसले नेपाली परम्परागत खानाका लागि महत्त्वपूर्ण पोषण डाटा सिर्जना गरेको छ। उल्लेखनीय नतिजाहरूमा गुन्द्रुकमा अत्याधिक उच्च क्याल्सियम (१०७८.४२ मिग्रा/१०० ग्राम कच्चा, ३०८.७६ मिग्रा/१०० ग्राम पकाएको) र सिङ्कीमा उल्लेखनीय फलाम स्तर (९.४६ मिग्रा/१०० ग्राम) समावेश छन्। थकाली खाना सेट विश्लेषणले पकाउने प्रक्रियामा पर्याप्त पोषक तत्त्वको हानिलाई देखाएको छ, जहाँ प्रोटिन संरक्षण पकाउने विधिहरूमा निर्भर गर्दै ४५% देखि ६५% सम्म रहेको छ।घोंघी फस्फरस रहेको छ, जसले अप्रयुक्त प्रोटिनको स्रोतलाई प्रतिनिधित्व गर्छ। योमरीले मध्यम पोषण घनत्व (५.१८% प्रोटीन, ४.४४ मिग्रा/१०० ग्राम फलाम) देखाएको छ, भने खाप्से तेलमा तारेकोले २०.१६% तेलको मात्रा रहेको छ, तापनि ११.४३% प्रोटिनलाई कायम राखेको छ।

गुणस्तर नियन्त्रण र विश्लेषणात्मक सेवाहरू

केन्द्रले बाह्य सेवा ग्राहीहरूका लागि २९८ विश्लेषणहरू सञ्चालन गरेको छ, जसबाट NPR ३३६२००/-को राजस्व सिर्जना भएको छ। ISO/IEC १७०२५:२०१७ मान्यताको दायराले अन्न, दालहरू र तेल बीउहरूमा २०० वटा प्यारामिटरहरूलाई ढाकेको छ। आन्तरिक गुणस्तर ऑडिटहरूले कागजात प्रक्रियाहरूमा सानो मात्रामा अनुरूप नहुने समस्याहरू पहिचान गरेको थियो, जसलाई पछि सच्याउने कार्यहरू

मार्फत सम्बोधन गरिएको छ। दक्षता परीक्षण कार्यक्रमहरूमा सहभागिताले ८५% प्यारामिटरहरूको लागि सन्तोषजनक z-स्कोर देखाएको छ, तथापि क्याल्सियम विश्लेषणको लागि विधि परिमार्जन आवश्यक रहेको छ।

संस्थागत विकास र क्षमता निर्माण

ISO/IEC १७०२५:२०१७ मा आधारित तालिम कार्यक्रमहरूले सरकारी र निजी क्षेत्रका ४५ जना सहभागीहरूलाई पुगेका छन्। शैक्षिक पर्यवेक्षणमा चामल र गहुँको गुणस्तर मूल्याङ्कनका लागि दुई बी.टेक थेसिस परियोजनाहरू समावेश थिए। प्रकाशन नतिजाहरूमा वार्षिक प्रतिवेदन २०७९/८० र GAP कार्यक्रम पत्रिकाहरू अंग्रजी र नेपालीमा समावेश छन्। इन्डोनेसिया र थाइल्याण्डमा AFACI मूल्याङ्कन जस्ता अन्तर्राष्ट्रिय कार्यशालाहरूमा कर्मचारीहरूको सहभागिताले प्राविधिक क्षमता र क्षेत्रीय नेटवर्किङलाई बढावा दिएको छ।

गम्भीर अवलोकनहरू र सीमाहरू

आर्थिक वर्षभरि केही चुनौतीहरू देखा परेका थिए। उपकरण र रसायन खरिदमा ढिलाइले परियोजनाका समयरेखालाई असर गरेको थियो, विशेष गरी बायोडिग्रेडेबल प्याकेजिंग र ग्लाइसेमिक इन्डेक्स अनुसन्धानका लागि। संस्थामा स्थायी अनुसन्धानकर्ताहरूको गम्भीर कमी रहेको छ; २९ पदहरू भएको प्रस्तावित संगठनात्मक संरचना आंशिक रूपमा रिक्त रहेको छ, जहाँ हाल १६ जना कर्मचारी मात्र रोजगारीमा रहेका छन्, जसले अनुसन्धान विस्तारलाई सीमित बनाएको छ। बजेट उपयोग ८६.४६% (विनियोजित: NPR **३१८८८०००**, खर्च: NPR **२७५७१.८७**) पुगेको थियो, तथापि भारित प्रगति उल्लेखनीय; ९८.४०% रहेको थियो। रैथाने खाना अभिलेखीकरणले पकाउने विधिहरूमा पोषक तत्त्व संरक्षण कारकहरूमा महत्त्वपूर्ण भिन्नता देखाएको छ, जसले मानकीकृत प्रोटोकलको आवश्यकतालाई सुझाव दिन्छ। केही विश्लेषणात्मक विधिहरू, विशेष गरी प्रशोधित खाद्यपदार्थहरूमा भिटामिन सी को लागि, चाहिने भन्दा बढी भेरियसन कोफिसिएन्ट (CV >१५%) देखाएका छन्, जसले विधिगत परिमार्जनको आवश्यकतालाई इङ्गित गर्छ।

रणनीतिक तथा नीतिगत आवश्यकता

अनुसन्धान नतिजाहरूले नेपालको कृषि र पोषण क्षेत्रका लागि तत्काल नीतिगत सुधार तथा नया रणनीतिहरू निहितार्थ राख्छन्। पोलिस गरिएको चामलमा भएको नाटकीय पोषण हानिले उपभोक्ता शिक्षा अभियान र सम्भावित फोर्टिफिकेशन अनिवार्यताको पक्षमा तर्क दिन्छ। अलैंचीका लागि फ्रिज ड्रायिंगको उत्कृष्ट प्रदर्शनले उत्पादन क्षेत्रहरूमा प्रशोधन पूर्वाधारमा लगानी प्राथमिकतालाई सुझाव दिन्छ। सामुदायिक खाद्यपदार्थ पोषण डाटाले परम्परागत खाद्यपदार्थहरूलाई राष्ट्रिय आहार दिशानिर्देशमा समावेश गर्ने लागि प्रमाण आधार प्रदान गर्छ। उच्च फलाम भएका परम्परागत प्रजातिहरूको पहिचानले जननिकन परिमार्जन बिना जैव-किल्लीकरणको मार्गहरू प्रदान गर्छ, जुन उपभोक्ता रुचिहरूसँग मेल खान्छ। च्याउ र भटमास उत्पादनहरूमा प्रशोधन नवापरिवार्तनहरूले साना किसानहरूको मूल्य श्रृंखलालाई समर्थन गर्दै प्रोटिन सुरक्षाका चिन्ताहरूलाई सम्बोधन गर्छन्। परम्परागत पेयहरूमा भाँचिएको चामलको सफल उपयोगले चक्रिय अर्थतन्त्र सिद्धान्तहरूलाई देखाउँछ, जुन खाद्य प्रशोधन क्षेत्रहरूमा लागू गर्न सकिन्छ।

EXECUTIVE SUMMARY

In the Fiscal Year 2081/82 (2024/25), the NFRC, under the auspices of the NARC, has made significant strides in advancing food science, technology, and post-harvest research to bolster Nepal's food security, nutrition, and agricultural sustainability objectives. The achievements of this year underscore NFRC's unwavering commitment to addressing both national and global priorities, particularly those articulated in the Agricultural Development Strategy (ADS) 2016 and the Sustainable Development Goals (SDGs), notably SDG 1, SDG 2, SDG 3, SDG 8, and SDG 12. Through focused research, innovative practices, and stakeholder collaboration, NFRC continues to spearhead advancements in food system resilience, economic development, and public health. This period marked significant advancement in the Centre's research portfolio, encompassing 16 active projects across diverse domains of food science, post-harvest technology, and nutritional analysis. The Centre's activities directly addressed critical gaps in Nepal's food system, from varietal assessment to ethnic food documentation, while maintaining its commitment to ISO/IEC 17025:2017 accreditation standards.

Key highlights from NFRC's research and activities during this fiscal year include:

Farm Management and Research Support Project Findings

The Farm Management and Research Support Project yielded substantial data on Nepal's agricultural commodities through comprehensive physical, chemical, and nutritional analyses. Analysis of six paddy varieties revealed moisture content ranging from 13.35% to 14.26%, with Ghaiya Chhotte demonstrating exceptionally high iron content (4.0 mg/100g) compared to improved varieties like Khumal 11 (0.73 mg/100g). This disparity appears to reflect genetic variation in iron uptake mechanisms and suggests potential for biofortification strategies. Phosphorus content showed inverse patterns, with Khumal 14 containing 105.87 mg/100g versus 56.49 mg/100g in Ghaiya Chhotte, indicating complex mineral distribution patterns across varieties.

Maize analysis across three varieties demonstrated protein content variations from 11.91% to 14.91%, with KWM-92 showing superior nutritional profiles. The 1000-kernel weight ranged from 201.45g to 275.02g, suggesting significant implications for milling efficiency and market value. *Kodo* millet samples (KLE-158 and KLE-159) exhibited notably high zinc content (5.46–6.95 mg/100g), positioning these varieties as potential contributors to addressing micronutrient deficiencies.

Legume analysis revealed striking differences between varieties, with chickpea protein content ranging from 18.79% to 23.24%, while mung bean (Panta-5) demonstrated comparable protein levels but distinct mineral profiles. The iron content in KPG-59 chickpea (6.23 mg/100g) exceeded that of mung bean (3.63 mg/100g) by nearly two-fold, though phosphorus showed opposite trends.

Large Cardamom Research and Processing Innovation

The large cardamom project represented a significant advancement in processing technology for this high-value crop. Comparative analysis of drying method, freeze drying, cabinet drying, and hybrid solar drying, revealed that freeze drying retained the highest

essential oil content (2.71%–5.58%), while traditional bhatti methods yielded 2.56%–5.20%. The dominant volatile compound, 1,8-cineole, ranged from 47.93% to 73.57% across samples, with freeze-dried Bharlangey variety achieving the highest concentration.

Yield percentages varied from 73.52% (Ramsai, hybrid solar) to 81.02% (Bharlangey, freeze drying), demonstrating the economic implications of processing method selection. The research identified 16 volatile compounds contributing to the aromatic profile, with significant variations based on drying temperature and duration. These findings have direct implications for farmer income, as freeze-dried cardamom commands premium prices exceeding traditional products by 200%.

Mushroom Processing and Value Addition Technologies

Development of ready-to-eat mushroom soup formulations using Response Surface Methodology yielded 10 distinct products with protein content ranging from 0.97% to 27.12%. Formulation 6, containing 50% mushroom and 50% milk solids, achieved optimal nutritional balance with 27.12% protein, 6.44 mg/100g iron, and 696.72 mg/100g phosphorus. The moisture content across formulations (6.08%–8.54%) ensured shelf stability while maintaining nutritional integrity.

Mushroom kimchi development trials demonstrated optimal fermentation at 5.76 days, achieving pH 3.41, protein content of 4.51%, and phosphorus retention of 50.55 mg/100g. Sensory evaluation scores peaked at 7.625±0.86 for the optimized formulation, indicating strong consumer acceptance potential.

Biodegradable Packaging Development

The cassava starch-based biodegradable film project produced 13 formulations with varying mechanical and barrier properties. Film thickness ranged from 0.15mm to 0.67mm, water vapor transmission rates from 18.01 to 41.99 g m^{-2} day^{-1}, and water absorption from 85.83% to 208.86%. Formulations with 7.75% glycerol exhibited optimal balance between flexibility and moisture barrier properties, though further optimization appears necessary for commercial viability.

Soybean Fermentation and Kinema Research

Analysis of 20 soybean varieties revealed protein content ranging from 18.79% to 23.25%, with ICCV-97207 showing superior nutritional profiles. Kinema fermentation studies demonstrated that six-day fermentation increased total phenolic content from 173.13 to 793.36 mg GAE/100g DM, while flavonoid content rose from 214.57 to 366.23 mg QE/100g DM. The IC50 values for antioxidant activity improved from 15.47 to 4.189 mg/mL, indicating enhanced bioactivity through controlled fermentation.

Rice Polishing and Nutritional Retention Studies

Comprehensive analysis of rice at different degrees of polishing (0–10%) revealed dramatic nutrient losses with increased processing. Iron content decreased by 83% (1.03 to 0.17 mg/100g), phosphorus by 60% (220.97 to 87.82 mg/100g), and calcium by 31% (14.02 to 9.60 mg/100g). Scanning electron microscopy confirmed progressive removal of aleurone layers, correlating with nutrient depletion. These findings challenge current milling practices and suggest the need for policy interventions to balance consumer preferences with nutritional retention.

Traditional Alcoholic Beverage Standardization

Analysis of traditional fermented beverages (thon, raksi, jand) from multiple locations revealed alcohol content ranging from 8.6% to 22.8%, with Mandandeupur millet samples achieving the highest concentrations. Optimization studies identified Balambu murcha as the superior starter culture, achieving optimal fermentation at 5.52 days. The study determined that 33.33% broken rice could be utilized in thon production without compromising sensory quality, offering economic benefits for processors.

Ethnic Food Documentation and Nutritional Profiling (AFCD+ Project)

The Asian Food Composition Database enhancement project analyzed 16 ethnic foods and 100 ingredients, generating critical nutritional data for Nepal's traditional cuisine. Notable findings included exceptionally high calcium content in gundruk (1078.42 mg/100g raw, 308.76 mg/100g cooked) and significant iron levels in sinki (9.46 mg/100g). The Thakali khana set analysis revealed substantial nutrient losses during cooking, with protein retention varying from 45% to 65% depending on preparation methods.

Ghonghi (Bellamya bengalensis), a mollusk consumed by ethnic communities, contained 176 mg/100g phosphorus when cooked, representing an underutilized protein source. Yomari demonstrated moderate nutritional density (5.18% protein, 4.44 mg/100g iron), while khapse's deep-fried preparation resulted in 20.16% fat content but retained 11.43% protein.

Quality Control and Analytical Services

The Centre conducted 503 analyses for external clients, generating revenue of NPR 503,600. The ISO/IEC 17025:2017 accreditation scope covered 200 parameters across cereals, legumes, and oilseeds. Internal quality audits identified minor non-conformities in documentation procedures, subsequently addressed through corrective actions. Participation in proficiency testing programs demonstrated satisfactory z-scores for 85% of parameters, though calcium analysis required method refinement.

Institutional Development and Capacity Building

Training programs on ISO/IEC 17025:2017 reached 45 participants from government and private sectors. Academic supervision included two B.Tech thesis projects on rice and wheat quality evaluation. Publication outputs comprised the Annual Report 2079/80 and GAP program leaflets in English and Nepali. Staff participation in international workshops (AFACI evaluations in Indonesia and Thailand) enhanced technical capacity and regional networking.

Critical Observations and Limitations

Several challenges emerged during the fiscal year. Equipment and chemicals procurement delays affected project timelines, particularly for the biodegradable packaging, and glycemic index research. The organization critically lacked permanent researchers; the proposed organizational structure with 29 positions remains partially unfilled, with only 16 staff currently employed, constraining research expansion. Budget utilization reached

93.2% (NPR 24,916,574.80 of 26,729,000 allocated), though capital expenditure showed lower efficiency at 91.3%. The ethnic food documentation revealed significant variations in nutrient retention factors across cooking methods, suggesting the need for standardized protocols. Some analytical methods, particularly for vitamin C in processed foods, showed higher coefficients of variation than desired (CV >15%), indicating methodological refinement requirements.

Strategic Implications and Policy Relevance

The research outcomes have immediate policy implications for Nepal's agricultural and nutrition sectors. The dramatic nutrient losses in polished rice argue for consumer education campaigns and potential fortification mandates. The superior performance of freeze-drying for cardamom suggests investment priorities for processing infrastructure in production regions. Ethnic food nutritional data provides evidence base for incorporating traditional foods into national dietary guidelines. The identification of high-iron traditional varieties offers pathways for biofortification without genetic modification, aligning with consumer preferences. Processing innovations in mushroom and soybean products address protein security concerns while supporting smallholder value chains. The successful utilization of broken rice in traditional beverages demonstrates circular economy principles applicable across food processing sectors.

1. INTRODUCTION

The National Food Research Centre (NFRC), a subsidiary of the Nepal Agricultural Research Council (NARC), is a forefront research and innovation Centre of food science, technology, and analytical research in Nepal. Established initially as the one-roomed Food Research Unit in 2051/52 B.S., the Centre is the central hub within NARC for innovative research on food quality, value addition, post-harvest technology, and safety standards, all of which are essential for promoting sustainable and resilient food systems. Since its inception, NFRC's research projects on quality analysis, value addition, storage, and packaging of food products have been continued. Refined technologies for value addition in the neglected and underutilized species (NUS), are emerging and are widely produced but farmers are not benefitted economically Realizing this, in the fiscal year 2020/21, the Food Research Division has been upgraded once again to the National Food Research Centre (NFRC) with greater responsibility for carrying out food research and development programs for seven provinces of the country. In F.Y, the Centre has also acquired ISO/IEC 17025:2017 Accreditation as a testing laboratory for 8 parameters in cereals, legumes, oilseeds, etc., in total 200 scopes.

1.1 Vision

The vision of the National Food Research Centre (NFRC) is to lead the research, development, and extension (R&D&E), and provide internationally valid analytical data in the field of food science, technology, and nutrition in the country under the policy, programs, pathways, and actions of the legislative government and in coordination with provincial and local governments.

- NFRC will act as a responsible Centre for NARC as a permanent member of Food Safety and Quality Recommendation Committee (FSQRC), the high-level committee of the Government of Nepal, to recommend policy, actions, pathways, and standards to ensure food safety and quality to protect human and animal health sustainably.
- The vision of NFRC focuses on poverty reduction, improving the nutritional status, and developing skills for the entrepreneurship of the populace, utilizing our vast array of indigenous resources and biodiversity.
- NFRC is also focused on the development of technologies for the minimization of food loss and waste.
- NFRC will promote commercial agriculture by creating value-added products from cereal crops, high-value crops, vegetables, fruits, livestock, and fisheries.
- NFRC will have a wider spectrum of stakeholders such as Farmers' groups, cooperatives, agro-entrepreneurs, research centres, food industries, and donor institutions at different government levels.
- NFRC will also provide internationally valid analytical data in agricultural and livestock, fisheries, poultry, herbs, and medicinal plants. The current 200 scopes will be expanded annually.

1.2 Mission

The Centre's mission aligns with Nepal's national Agricultural Development Strategy (ADS), 2016, and the global Sustainable Development Goals (SDGs). In particular, NFRC's work supports goals to eradicate poverty (SDG 1), achieve zero hunger (SDG 2), improve health and well-being (SDG 3), promote sustainable industrial innovation (SDG 9), ensure responsible consumption (SDG 12), and address climate change (SDG 13). Thus, NFRC's mission is guided by the principle of strengthening Nepal's food systems to address food and nutrition security, improve dietary quality and health, and support the socio-economic development of rural and urban communities with context-specific solutions and innovations.

In fulfilling this mission, NFRC engages in comprehensive research across four main areas:

- Advisory to the Government of Nepal: As a permanent member of FSQRC, NFRC will continuously help the Government of Nepal to formulate the policies, action tracts, pathways with objectively verifiable indicators, standards of food and feed to ensure one health and sustainable utilization of natural resources for inclusive governance and socioeconomic growth.
- Nutritional and quality analysis: NFRC conducts thorough analyses of cereals, legumes, horticultural crops, and animal products to determine their physical, milling, chemical, and nutritional profiles as a part of varietal and breed development programmes through its ISO/IEC 17025:2017 Accredited testing laboratory. Such studies not only enhance understanding of Nepal's staple foods but also enable the development of fortified and nutrient-rich products that meet dietary needs. For instance, high-protein wheat and carbohydrate-rich maize varieties identified through NFRC's work can support local food security by enhancing the nutritional value of Nepalese diets.
- Value addition and post-harvest technology development: A cornerstone of NFRC's work is to develop and validate technologies that increase the marketability and shelf life of locally grown produce. Recent projects in perishables such as mushrooms, mangoes, and tomato processing have led to value-added products like powders and purees that retain high nutritional quality and are less susceptible to spoilage. Similarly, advanced drying technology, such as freeze drying of large cardamom, can enhance its market value by more than 2000 %. *Kinema* and processed products based on it can be a good dietary source for better health and longevity. These technologies are directly aimed at increasing market value astronomically, minimizing food loss, addressing Nepal's challenge due to the limited infrastructure for cold storage and transportation, and enhancing nutritional and healthy outcomes.
- Ethnic food documentation and standardization: Nepal's rich culinary heritage includes numerous ethnic foods and fermentation practices that contribute to dietary diversity and cultural identity. NFRC's work in documenting, standardizing, and optimizing ethnic foods such as indigenous alcoholic beverages, *kinema*, and pickles ensures these foods can be safely produced and marketed. Research on novel probiotic microorganisms will also provide new economic opportunities while

preserving cultural heritage. This effort supports NFRC's role in food innovation and opens avenues for Nepalese ethnic foods to enter national and global markets.

- Research and development support for emerging technologies: NFRC has been working on applying extrusion and fermentation technology to develop sustainable plant-based protein alternatives and fortified products. Innovations in this area, such as soybean-based products, meat analogs, and value-added cereal products, align with global trends towards healthier, plant-forward diets and reduce dependency on imported protein sources. Moreover, focus is also on developing whey protein concentrate and hydrolysate (which could also be incorporated into an infant's diet). This work contributes to Nepal's food sovereignty and environmental sustainability by diversifying protein sources.

1.3 Objectives

The overall objective is to develop efficient post-production technologies for both durable and perishable agricultural produce to increase food availability and strengthen the food and nutrition security of the country. The specific objectives are the following:

- To develop appropriate technologies to minimize quantitative and qualitative postharvest losses of both perishable and nonperishable products.
- To develop appropriate technology for the preservation and processing of spices, herbs, medicinal plants, and fungi.
- To develop a package of milling loss recovery and quality evaluation systems of cereals, legumes, and oilseeds of local and improved varieties.
- To develop low-cost food recipes and plant-based products based on minor crops, legumes, oilseeds, and cereals.
- Value addition and preservation, exploration into novel animal food commodities.
- To provide internally valid analytical data for stakeholders.
- To document the developed technologies in journals, leaflets, booklets, seminar papers, and proceedings.
- To disseminate developed post-harvest technologies through on-farm research, training, and media such as TV, radio, and leaflets to the farmers, processors, extension personnel, and individuals.
- To prepare proposals and execute projects on post-harvest aspects for joint collaborative research work with international organizations.

1.4 Strategy

- NFRC identifies research problems and collects the research issues of food technology through regular interaction with stakeholders.
- NFRC formulates research programs based on real needs and potentialities at the local level.

- Novel research in the field of food science and technology, and nutrition will be implemented through a glocalization approach.
- NFRC follows a group approach for validating and disseminating newly developed technology through farmers' groups and cooperatives.
- Infrastructure, equipment, and human development will be emphasized. Advanced-level facilities, equipment, training, and higher degree opportunities will be provided to the researchers to fulfill the technology demand in the future
- Human resources will be augmented according to the required technical manpower in each discipline of food science and technology.

1.5 Mandate

- खाद्य वस्तु र प्रविधि, उद्यमशिलता सम्बन्धी अध्ययन अनुसन्धान, अनुसरण, पहिचान/विकास तथा प्रवर्धन ।
- नेपालका मौलिक खाद्य वस्तुहरुको संग्रह अद्यावधिक ।
- खाद्य, खाद्य प्रविधि तथा गुण नियन्त्रण नीति निर्माणमा सहयोग ।
- खाद्य प्रविधि संग सम्बन्धी जनशक्तिहरुको क्षमता अभिवृद्धि ।
- परिषद्को स्वीकृतिमा राष्ट्रिय तथा अन्तराष्ट्रिय संघ संस्थाहरुसंग समन्वय तथा सहकार्य ।

1.6 Current Thrust Areas for Research

The NFRC has identified the following key focus areas for its research activities:

- Glycemic Index of Local Crops: NFRC is researching to determine the glycemic index of locally-grown crops and agricultural commodities. This information is crucial for understanding the nutritional profile and potential health benefits of these food products.
- Preservation and Processing of High-Value Commodities: NFRC is undertaking studies on the preservation and processing of high-value crops such as large cardamom, ginger, turmeric, potato, banana, mango, kiwi, coffee, pear, and plum. The aim is to develop effective techniques for extending the shelf-life and improving the quality of these important horticultural commodities.
- Value Addition and Nutritional Analysis: Researchers at NFRC are actively engaged in value addition and comprehensive nutritional analysis of staple grains (rice, maize, wheat), grain legumes, oilseeds, honey, and goat milk, whey protein concentrate and hydrolysate. The objective is to enhance the nutritional profile and explore potential applications of these agricultural products.
- Functional and Bioactive Components: NFRC is investigating various horticultural crops' functional and bioactive properties. This research provides insights into the health-promoting phytochemicals and other beneficial compounds present in these food sources.

1.7 Infrastructure and Facilities

Facility Overview

The National Food Research Centre (NFRC) occupies a total area of 0.1486 hectares (16,000 square feet), with the main building covering 0.0514 hectares (5,534 square feet). This includes an office building with 2,542 square feet of laboratory facilities and a 2,992 square feet pilot plant.

Fully Equipped Laboratories

NFRC maintains an ISO/IEC 17025:2017 Accredited fully equipped food analysis laboratory capable of conducting advanced physico-chemical analysis of both durable and perishable agricultural products.

Pilot Plant Facilities

The center also houses a well-equipped pilot plant for product development and testing from a wide range of food commodities, including cereals, legumes, oilseeds, horticultural crops, and animal-based products with wet chemistry, High-performance liquid chromatography (HPLC), Gas Chromatography Mass Spectrometry (GCMS), Atomic Absorption Spectroscopy (AAS), and Near Infrared Spectroscopy (NIRS).

Additional Facilities

Other available facilities and capabilities at NFRC include:

- Milling analysis of cereals and grain legumes
- Freeze, microwave, spray, vacuum, and solar drying facilities
- Value-added product development from underutilized cereal crops
- Preservation and maintenance of industrially important microorganisms
- Oil extraction from oilseeds
- Extraction of essential oils and oleoresins
- Utilization of food processing by-products
- Analysis of bioactive properties of horticultural crops and spices
- Instrumental textural and sensorial analysis
- Training programs for small-scale farmers and food entrepreneurs
- In-plant training and dissertation work for food technology students
- Food-related consultancy services

Detailed information about the laboratory facilities is provided in Annex 1.

1.8 Organizational Structure and Human Resources

Staffing

In the Fiscal Year 2071/82, the National Food Research Centre (NFRC) had a total of 5 staff members, including:

- 1 Senior Scientist (S-4)
- 1 Scientist (S-2)
- 1 Accounts Officer (A-6)
- 8 Graduate Research Analysts, 2 Thesis Students, and 2 volunteers
- 2 Technicians (T1), 3 administrative, and 4 helpers involved in research and overall management activities

Annex 2 details NFRC's current organizational structure, and Annex 14 outlines the proposed human resource and organizational structure.

2. WORKING CONTEXT

2.1 Socioeconomic Target Group

The NFRC directs its efforts towards a diverse range of stakeholders whose livelihoods are intrinsically linked to agriculture and food processing in Nepal. These include smallholder farmers, cottage industries, agro-entrepreneurs, and food technology institutions. These groups are the backbone of Nepal's food value chain. By providing them with accessible, affordable, and impactful post-harvest and value addition technologies, the NFRC aims to achieve multiple objectives: improving rural incomes, enhancing food quality, and strengthening national food security.

Through its extensive fieldwork and comprehensive extension services, NFRC engages directly with local communities across Nepal. This close interaction enables the center to deeply understand the unique challenges and needs faced by these stakeholders, which in turn informs and shapes the center's research priorities. NFRC's training programs, specifically for small-scale farmers and agro-entrepreneurs, focus on imparting practical skills in areas such as post-harvest handling, processing, and value addition. By empowering these stakeholders with these crucial capabilities, NFRC ensures they are equipped to increase their product's value and access new, lucrative markets. These initiatives not only address immediate food security concerns but also contribute to the broader socioeconomic upliftment of Nepal's rural populace.

2.2 Command Area

The research activities undertaken by NFRC span the entirety of Nepal's diverse geographic regions and ecological zones, each with its own unique agricultural characteristics and challenges. The center's deep expertise in post-harvest technology and food processing allows it to develop region-specific solutions tailored to the storage, packaging, and value addition needs of the local contexts. This enables NFRC to address the diverse climatic conditions, agricultural systems, and crop profiles found across Nepal, promoting food security and resilience on a truly national scale.

2.3 Food and Nutritional Security

2.3.1 Food Security

NFRC's contributions to enhancing food security in Nepal are manifold:

- Reducing Post-Harvest Losses: NFRC's innovations in drying, powdering, and preserving techniques for seasonal crops have significantly reduced post-harvest losses. This allows for year-round availability of nutritious foods, addressing seasonal scarcity and reducing the country's reliance on imports.
- Improving Shelf-Life and Marketability: The center's research on extending the shelf-life and enhancing the marketability of Nepalese crops has been crucial in ensuring the sustained supply and commercial viability of these agricultural commodities.

2.3.2 Nutritional Security

NFRC's research also contributes to improving the nutritional security of Nepal's population:

- Nutritional Profiling: In-depth analyses of the nutritional profiles of staple crops like maize, wheat, and bananas, as well as underutilized crops and horticultural commodities, have provided valuable insights.
- Promoting Nutrient-Dense Foods: NFRC's initiatives to create fortified food products and introduce nutrient-rich alternative crops into the Nepalese diet have been instrumental in addressing macro- and micronutrient deficiencies, ensuring access to sustainable sources of protein, fibre, and essential vitamins for rural communities.

2.4 Food Safety

Ensuring the safety and quality of food products is a core aspect of NFRC's mandate. The center conducts rigorous microbial, chemical, and sensory evaluations of all food items developed through its research and innovation efforts. This includes measures such as rancidity testing, microbial contamination screening, and comprehensive shelf-life studies. These stringent quality control measures are crucial in ensuring that the food products created by NFRC not only meet national and international safety standards but also foster consumer confidence in locally-produced Nepalese foods. Moreover, the Chief of the NFRC is a member of the Food Safety and Standard Advisory Committee, the higher advisory body, which recommends to the Government for the promulgation of Food Safety policies and standards.

2.5 Major Stakeholders

NFRC operates within a robust network of collaborators and partners, including:

- Government and Policy Bodies: Partnerships with the National Planning Commission, Ministry of Agriculture and Livestock Development (MoALD), and other relevant agencies enable NFRC to closely align its work with national agricultural and food policies. This ensures that the center's research and innovations contribute to the formulation of evidence-based strategies for strengthening food security and nutrition in Nepal.
- Farmers and Producer Cooperatives: NFRC's direct collaborations with farmers and their cooperatives allow the center to tailor its research and innovations to the actual needs and challenges faced by the agricultural community. This close interaction helps bridge the gap between laboratory research and practical field application.
- Academic and Research Institutions: Collaborations with NARC's research centers, universities, and other research organizations foster knowledge exchange, capacity building, and research synergy. This expanded network enhances NFRC's reach and impact across various sectors.
- International Organizations: Partnerships with global agencies such as FAO, Feed the Future-USAID, and the Asian Food and Agriculture Cooperation Initiative (AFACI) provide NFRC with financial and technical support. This enables the center to address food-related challenges of both local and global significance.

2.6 Adopted Technologies

- At the NARC, our team plays a crucial role in achieving the Sustainable Development Goals (SDGs) in Nepal. We focus on addressing various issues related to agricultural commercialization, post-harvest management and processing, cost-effective VA, food and nutrition security (F&NS), food safety, minimizing FLW, and by-product utilization.

To tackle these challenges, our team has developed several technologies that enhance food production, processing, and preservation. Some of the recent technologies developed include:

- Freeze Drying Technology for large cardamom (2024): This technology will result in premium quality large cardamom without loss of pink colour.
- Microwave Drying Technology for Akbare Chilli (2024): This technology is extremely fast drying (2-4 min) to dry the Akbare Chilli without loss of red colour
- Mushroom Drying and Power Technology (2023): This technology will open avenues for mushroom processing industries and technology to increase the shelf life of mushrooms.
- Kinema-Meat Pickle (2023): It will provide a healthy plant-based savory product and add value to soybeans, promoting the expansion of soybean cultivation.

- Optimized Goat Cheese Processing (2023). The optimization technology for $CaCl_2$ and culturing time will ensure consistent and high-quality goat cheese enhancing their market value.
- Weaning food developed from malted barley (2022): This technology improves the nutritional value of baby foods by incorporating malted barley, which is rich in essential nutrients and minerals, preventing malnutrition in infants.
- Good Agricultural Practices (GAP) and Package of Practices for Cardamom (2019): Implementing GAP and the package of practices enhances the quality and yield of cardamom, benefiting farmers with better prices and improved livelihoods.
- Package of practices and GAP for leafy vegetables (2019): This technology improves the quality and yield of leafy vegetables, which are important sources of vitamins and minerals.
- Coffee processing and post-harvest technology (2018): This technology enhances the quality and value of coffee products, leading to better prices for farmers and improved livelihoods.
- Goat cheese production technology (2018): This technology improves the quality and value of goat cheese products, benefiting farmers with better prices and improved livelihoods.
- By-product utilization technology from sweet orange (peel candy) (2018): This technology reduces food waste by utilizing sweet orange by-products. The sweet orange peel candy provides valuable nutrition.
- VA technology for wood apple (*bael*) (2018): This technology enhances the value of wood apple products, which are rich in nutrients and antioxidants.
- Post-harvest and VA technology (jam, candy, wine) for kiwi, pear, and plum (2018): This technology improves the quality and value of kiwi, pear, and plum products, which are important sources of vitamins and minerals.
- Post-harvest and VA technology for underutilized fruits (apricot, walnut, chuiri), candy, and wine) (2019): This technology enhances the value of underutilized fruits and oilseeds like apricot, walnut, and chuiri, improving farmers' income.
- Malting technology for proso millet, foxtail millet, and sorghum (2018): This technology improves the nutritional value of millet and sorghum-based foods by increasing the bioavailability of essential nutrients such as iron and zinc.
- Package of practices and GAP for cauliflower and broccoli (2018): This technology improves the quality and yield of cauliflower and broccoli, which are important sources of vitamins and minerals.
- Package of practices and GAP for cabbage (2017): This technology improves the quality and yield of cabbage, which is a crucial source of vitamin C.
- GAP for tea and coffee (2012): This technology enhances the quality and yield of tea and coffee, which are important sources of caffeine and antioxidants.
- Locally adaptable solar drying technology for fish (2010): This technology extends the shelf-life of fish, reduces post-harvest losses, and increases fish availability. It is suitable for small-scale fishers in Nepal who lack refrigeration facilities. The locally adaptable solar drying technology uses solar energy and locally available materials for effective fish preservation while maintaining its nutritional value.

- Processing technology for betel nut (2010): This technology increases the shelf-life and market value of betel nuts, an important cash crop in Nepal.
- Processing and VA technology for potato flour (2010): The NFRC has developed a technology for processing potatoes into flour, offering an alternative source of income for farmers. Potato flour can be used as a substitute for wheat flour in various food products.
- Processing and VA technology (bread, biscuit, cake, noodles) from finger millet and buckwheat (2006): This technology transforms finger millet and buckwheat into nutritious food products like bread, biscuit, cake, and noodles, which have a longer shelf-life, reducing food waste and enhancing food security.
- Technology for the development of apple juice concentrate (2006): This technology processes apples into juice concentrate, extending their shelf-life and market value.
- Zero energy cool chamber storage technology for mushrooms (2004): This technology stores mushrooms in zero energy cool chambers constructed from locally available materials, extending their shelf-life and maintaining quality.

In conclusion, the NFRC has developed various technologies in the field of FS&T to achieve SDGs related to food and nutrition security, food safety, and the reduction of post-harvest losses and waste. These technologies are crucial for the commercialization of agriculture in Nepal, increasing crop value, and providing alternative income sources for farmers. However, further research, development, and adequate resources are needed to improve the efficiency, effectiveness, and widespread adoption of these technologies, especially among small-scale farmers.

2.7 Emerging Problems

NFRC's research agenda is shaped by several pressing issues and challenges that continue to impact Nepal's food and agricultural sector:

- Significant Food Loss and Waste: Nepal experiences substantial post-harvest losses, currently estimated at 25-30% of total agricultural production. This burden not only affects food availability but also significantly impacts the country's overall GDP. Developing efficient storage and preservation methods is a crucial focus area for NFRC to address this pressing challenge.

- Limited Utilization of Indigenous Crops: Nepal is home to a wealth of underutilized and indigenous climate-smart crops, such as millet, buckwheat, and sorghum, which possess immense nutritional and economic potential. NFRC is working to promote the value addition and quality enhancement of these crops, to integrate them into mainstream diets and market channels.

- Fragmented Research Initiatives: A lack of coordination and strategic alignment across the various research institutions in Nepal has led to redundancy and missed opportunities for impactful collaborations. NFRC is actively strengthening partnerships with academic and extension institutions to ensure that research efforts are cohesive, synergistic, and effectively disseminated to the intended beneficiaries on time.

- By addressing these emerging problems through its multifaceted research, NFRC is poised to play a pivotal role in enhancing Nepal's food and nutritional security, while also contributing to the sustainable development of the country's agricultural and food processing sectors

2.8 Researchable Issues

The National Food Research Centre (NFRC) has identified several key areas of research focus to address the pressing challenges faced by Nepal's food and agricultural sector:

- Reduction of Post-Harvest Losses: NFRC's research efforts are directed toward developing cost-effective packaging, preservation, and storage solutions. The aim is to prevent spoilage and extend the lifespan of agricultural commodities, particularly perishable crops, thereby reducing the significant post-harvest losses experienced in Nepal.
- Nutritional and Functional Analysis: By conducting in-depth analyses to identify the bioactive compounds and nutritional properties of underutilized crops, NFRC's research promotes the diversification of Nepalese diets and enhances overall nutritional outcomes for the population.
- Cost-Effective, and Advanced Value Addition and Product Formulation: NFRC is dedicated to developing affordable technologies for creating value-added products. And high-value products for niche market. This aims to improve the market appeal of local agricultural produce and generate higher incomes for producers.
- Food Safety Enhancement: NFRC's research focuses on improving food safety across the agricultural value chain, from farm to table. This includes identifying and mitigating sources of contamination to ensure the safe consumption of food products.
- Medicinal, Functional, and Bioactive Properties of Indigenous Crops: Exploring the unique health benefits and bioactive compounds present in Nepal's indigenous and underutilized plant species is a key area of research. This promotes advancements in both nutritional and therapeutic applications.
- Ethnic Food Documentation and Standardization: NFRC undertakes systematic documentation and standardization of traditional ethnic foods, with the goal of preserving the country's rich culinary heritage while ensuring quality and consistency.
- Plant Protein Valorization: Research on plant-based proteins aims to develop sustainable, high-quality alternatives that can meet the evolving nutritional needs of the Nepalese population.
- Technology Dissemination: NFRC plays a crucial role in facilitating the adoption of the technologies and innovations it develops. This helps farmers and producers integrate improved practices, supporting sustainable development in local food systems.

2.9 Services

In addition to its research activities, NFRC also provides a range of specialized services to support various stakeholders in Nepal's food and agricultural sector:

- Quality Analysis of Food Commodities: NFRC conducts quality assessments of food commodities from various centers, programs, and the Directorate of NARC through ISO/IEC 17025:2017 accredited testing laboratory. This ensures compliance with standards and enhances the reliability of these products.
- Technical Advisory Services for Agri-Entrepreneurs: NFRC's team of experts offers advisory services to help agri-entrepreneurs improve their operational efficiency, product quality, and market competitiveness.
- Technical Support for Food Industries: NFRC provides specialized technical assistance to food industries, promoting innovation, quality control, and sustainable production practices.
- Technical Support for Commercial Farmers: NFRC offers technical support to commercial farmers, aiming to optimize their crop yield, quality, and profitability through the application of improved agricultural practices.
- Technology Incubation for Processing and Product Development: NFRC's technology incubation unit supports stakeholders in the areas of processing, value addition, and product development. This fosters innovation and enables the realization of startup potential in the agri-food sector.
- Policy Advice on Food and Nutrition Security and Food Systems Transformation: NFRC provides policy advice to key institutions, including the National Planning Commission and various ministries, to strengthen food and nutrition security, promote value chains and agricultural commercialization, and enhance food safety standards.
- Advisory Role in Food Safety and Standards: As a member of the Food Safety and Standards Advisory Committee, the apex body advising the Government of Nepal, NFRC contributes to maintaining national food safety standards, recommending essential food standards for public health and safety, and promoting sustainable food and agro-based industries.

Through this comprehensive range of research activities and specialized services, NFRC is well-positioned to drive transformative changes in Nepal's food and agricultural landscape, ultimately contributing to the country's food and nutritional security, as well as the socioeconomic development of its rural communities.

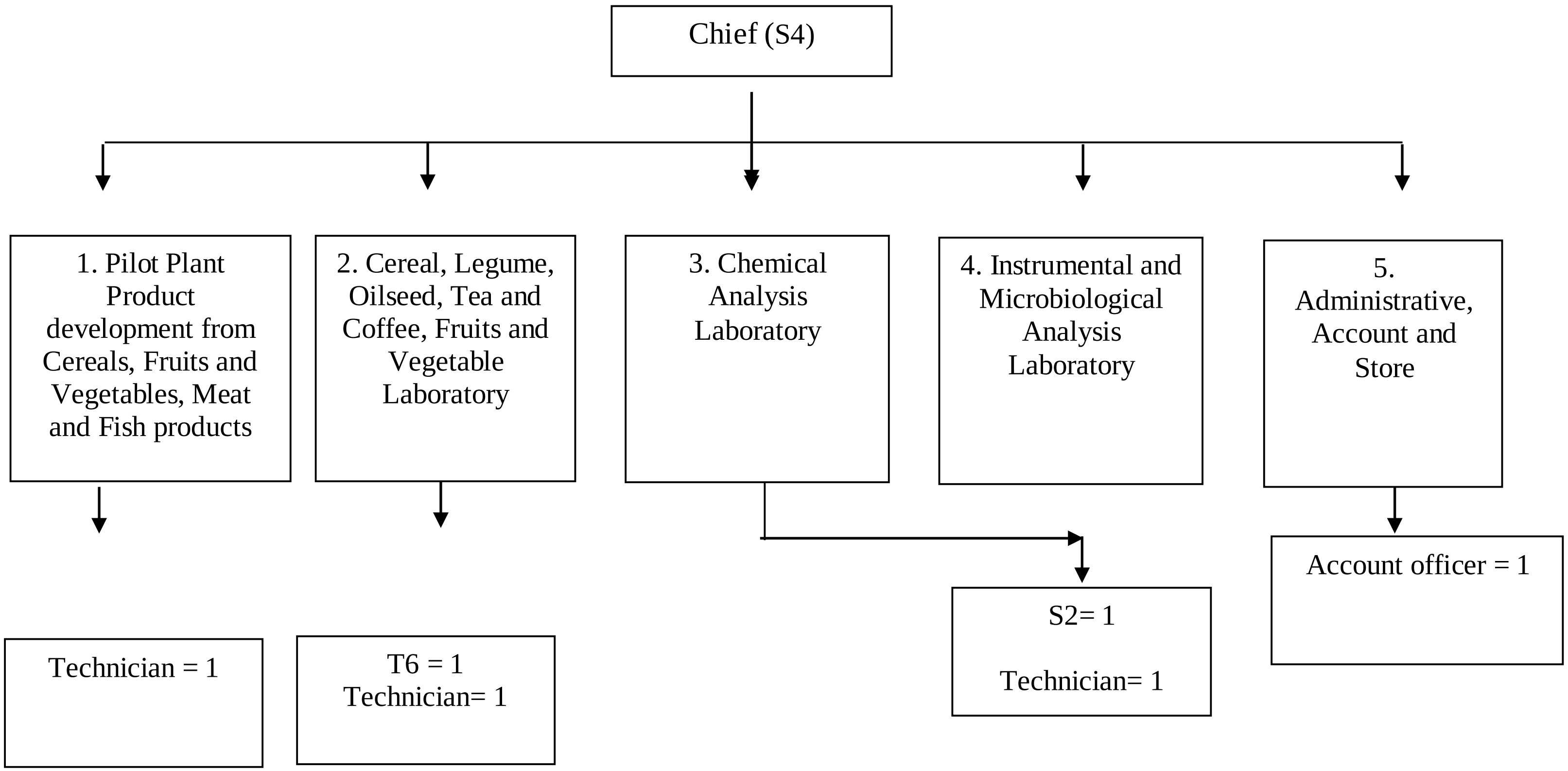

Figure 1: Existing organizational structure of National Food Research Centre (FY 2081/82)

3. RESEARCH HIGHLIGHTS

The executive summary of projects conducted last FY 2023/24 is highlighted below.

3.1. Farm Management and Research Support Project.

In the fiscal year 2081/82 (20243/25), the Farm Management and Research Support Project focused on advancing the understanding of Nepal's major agricultural commodities through comprehensive physical, chemical, and nutritional analyses for different NARC research centres, commodity programs, farmers, Small, Medium, and Large-Scale Enterprises (SMLSEs), governmental agencies, and other stakeholders. These efforts were instrumental in identifying the quality, nutritional value, and potential applications of various crops and products critical to Nepal's food security and improvement of the nutritional status of people. This year's research highlights cover the analysis of cereals, legumes, horticultural crops, and animal-based products, providing actionable insights for crop improvement, dietary enhancement, and market diversification.

3.1.1 Assessment of physical, chemical, milling, bioactive, cooking, and functional qualities of cereals, legumes, and oilseeds

- **Paddy**

Paddy rice, scientifically known as *Oryza sativa,* is a vital staple food for over half of the world's population, particularly in Asia. It serves as a primary source of carbohydrates, protein and essential nutrients and is naturally gluten-free. Rice cultivation is deeply integrated into the cultural fabric of many Asian societies, with traditional practices and festivals celebrating the planting and harvesting seasons (Zhao *et al.,* 2021)**.** Six samples of paddy were received from the National Agronomy Research center, Khumaltar. These were subjected to chemical analysis (Moisture, Iron and Phosphorus) (Table 1) according to AACC, (2000) and AOAC, (2023)

The result is significantly ($p < 0.05$) higher in Khumal 11 (14.26±0.04 %) and lower in Ghaiya Gorkhali (13.35±0.07 %) (Table 1). After harvest, moisture content is influenced by relative humidity, safe storage level to prevent spoilage, and maintaining quality. High moisture content in milled rice is affected by harvesting conditions, inadequate post-harvest handling and inefficiencies in the milling process (Kim and Lee, 2013).

Iron Content

Iron content of different variety of rice ranges from 4 to 0.73 mg/100g.The iron content of the six different paddy is significantly ($p < 0.05$) higher in Ghaiya Chhotte with a value 4±0.08 (mg/100g) and lower in Khumal 11 with a value 0.73±0.17 (mg/100g). The mechanisms of iron uptake and transport within the rice plant play a crucial role as genes involved in iron transport and regulate how efficiently rice can absorb from soil. Different varieties with similar expression of the genes may have comparable iron value in the polished rice (Bashir *et al.,* 2010).

Table 1. Chemical properties of paddy samples

Sample name	Moisture	Iron(mg/100g)	Phosphorus
Khumal 14	14.19±0.06^{a}	3.26±0.6^{ab}	105.87±4.99^{a}
Khumal 11	14.26±0.04^{a}	0.73±0.17^{c}	79.56±10.39^{b}
Ghaiya Chobo	13.7±0.20^{b}	1.03±0.12^{c}	78.65±7.85^{b}
Ghaiya Gorkhali	13.35±0.07^{c}	2.4±0.87^{b}	81.85±8.11^{b}
Ghaiya Chhotte	13.6±0.13^{b}	4±0.08^{a}	56.49±5.26^{c}
Ghaiya Bhutte	14.2±0.14^{a}	2.39±0.73^{b}	92.72±11.33^{b}

Note: Values expressed are mean ± standard deviation. Means in the row with different superscripts are significantly at $p < 0.05$. All the data are on a wet basis.

Phosphorous Content

Phosphorus content of different varieties of rice ranges from 105.87 to 56.49 mg/100g (Table 1). The Phosphorus content of the six different paddy is significantly ($p< 0.05$) higher in Khumal 14 with a value 105.87±4.99 (mg/100g) and lower in Ghaiya Chhotte with a value 56.49±5.26 (mg/100g). The differences in phosphorus content in different rice varieties are influenced by their genetic makeup, which affects how efficiently they absorb phosphorus, the structure and size of their root systems, and how they distribute growth between roots, stems and grains under different phosphorus conditions in the environment (Vejchasarn *et al*., 2016).

One Paddy sample was obtained from the National Food Research Centre. These were subjected to L/b ratio, Proximate, Minerals analysis, and cooking quality (Table 2). The L/B ratio of milled rice was found to be 3.37. The proximate analysis provides Moisture (%), Fat (%), Crude fiber (%), Protein (%), and Ash (%) were found to be 15.23%, 0.85%, 0.72%, 8.91%, and 0.53%, respectively. The determined moisture (%) falls under the safe range for storage stability (<15–16%), ensuring minimal microbial growth. The low-fat content of rice contributes to good shelf life but low caloric density from lipids. Indicates moderate crude fiber content, beneficial for digestion but lower compared to less-polished or brown rice (Juliano &Tuaño, 2018). Within the typical range of milled rice (7–9%), this suggests sufficient protein contribution for a staple crop. Ash% reflects mineral content, slightly reduced compared to unpolished rice due to polishing (Juliano &Tuaño, 2018). The Iron (mg/100g), Calcium (mg/100g), and Phosphorus (mg/100g) were found to be 0.44, 87.20, and 198.47, respectively. Iron (0.44 mg/100g) was found to be low, confirming that polishing reduces iron concentration (Prom-u-thai et al., 2009). Calcium (87.20 mg/100g) and Phosphorus (198.47 mg/100g)**,** however, both values indicate moderate mineral retention; phosphorus is mainly stored in the aleurone layer, so its presence reflects partial preservation of outer layers (Puri et al., 2014) For the cooking properties, Kernel Elongation Ratio (KER), Volume Expansion Ratio (VER), Water Uptake Ratio (WUR), and water-soluble ash (WSA) of cooked paddy were found to be 1.67, 3.67 and 2.73, and 0.58 %, respectively.

Table 2: Physical, chemical, and cooking properties of rice.

SN	Parameters	Samples
1	Moisture (%)	15.23±0.39
2	Fat (%)	0.85±0.12
3	Crude fiber (%)	0.72±0.08
4	Protein (%)	8.91±0.56
5	Ash (%)	0.53±0.08
6	Iron (mg/100g)	0.44±0.03
7	Calcium (mg/100g)	87.20±2.50
8	Phosphorus (mg/100g)	198.47±0.43
9	KER	1.67±0.13
10	VER	3.67±0.02
11	WUR	2.73±0.06
12	WSA (%)	0.58±0.03
13	L/B ratio	3.37±0.20

Note: Values expressed are mean ± standard deviation.

Physical, Milling, Proximate, Minerals, Cooking, Amylose and Alkali spreading were analyzed two different varieties of paddy samples from the National Plant Breeding and Genetic Research Centre, Khumaltar, Lalitpur (Table 3).

Table 3: Physical, chemical, and cooking properties of rice

SN	Parameter	NR 11475-B-B-4	Lumle-2
1	Moisture (%)	10.24±0.32^{b}	10.98±0.06^{a}
2	Protein (%)	20.57±0.52^{b}	23.25±1.19^{a}
3	Fat (%)	2.66±0.61^{a}	2.53±0.39 ^{a}
4	Ash (%)	2.49±0.04^{a}	2.17±0.09^{b}
5	Crude fiber (%)	11.11±0.35^{b}	12.10±0.24^{a}
6	Iron (mg/100g)	6.23±0.68^{a}	5.32±0.92^{a}
7	Phosphorous (mg/100g)	305.49±1.55^{a}	281.92±4.58^{b}
8	Calcium (mg/100g)	121.89±5.86^{a}	121.12±24.12^{a}

Note: Values expressed are mean ± standard deviation. Values with different letters in the superscripts differ significantly ($p < 0.05$).

Moisture (%), Protein (%), and Crude fiber (%) content are significantly ($p < 0.05$) high in Lumle-2, with a very good storage stability, better nutritional value compared to other varieties. Ash (%), Phosphorous (mg/100g) are significantly ($p < 0.05$) high in NR 11475-B-B-4 variety. There is no significant ($p < 0.05$) difference in Fat (%), Iron (mg/100g), and Calcium (mg/100g), making it a better diet for people with an iron deficiency and contributing to bone health and metabolic functions (Prakash et al., 2010).

- **Maize**

Three samples of Maize were received from National Plant Breeding and Genetics Research Center, which were subjected to physical analysis (1000 kernel weight, l/b ratio and Bulk Density) and chemical analysis (Moisture, Fat, Protein, Crude Fiber, Total Ash, Iron, Zinc, Phosphorus) (Table 4).

Table 4: Chemical analysis of maize

Sampl	Moisture	Fat %	Protein %	Crude	Total Ash	Phosphorus,
KWM	11.83±0.02	4.76±0.06	13.61±0.24	3.75±0.20	1.46±0.003	293.31±1.7
KWM	11.51±0.05	4.51±0.26	14.91±0.23	3.86±0.35	1.45±0.001	345.44±1.9
KWM	11.8±0.08^{a}	2.83±0.23	11.91±0.15	3.71±0.22	1.2±0.003^{c}	251.67±3.0

Note: Values are the mean ± standard deviation obtained from the triplicate data. Different alphabets in the same column indicate significant difference ($p< 0.05$). All data are in dry basis.

Under chemical analysis, the moisture content was found to be 11.51-11.83% and was significantly higher in KWM-91 and KWM-93. The fat content was found to be 2.83-4.76%. and significantly higher in KWM-91 and KWM-92. The protein content was in the range of 11.91-14.91% and was found significantly higher in KWM-92. The obtained result is similar to the findings of Kabir et al, 2019, who reported a fat content of 4.27-5.44% and a protein content of 9.46-13.11% across five maize varieties. The crude fiber was found to be 3.71-3.86% and was not significantly different from each other. This value was slightly higher than that reported by Kabir et al., (2019), who observed crude fibre in the range of 1.24-2.07% across five maize varieties. This could be due to varietal or geographic origin differences. The total ash was found to be 1.2-1.46% and was significantly higher in KWM-91. The ash content indicated the presence of considerable mineral fractions, contributing to the nutritional value of the samples. The phosphorus content was in the range of 251.67-345.44% and was significantly higher in KWM-92. When converted to percentage, this corresponds to 0.25-0.35%, which is comparable to the findings of Kabir et al., (2019), who reported 0.30-0.39% phosphorus.

Under physical analysis, L/B ratio was found to be 1.12-1.27 and was significantly greater in Maize 3 (Table 5). 1000 kernel weight was found to be 201.24-275.02 g and was significantly greater in Maize 2. Yadav et al., (2025) reported 154.71-250.23 g for 1000 kernel weight across 100 varieties of Maize, which is in line with our result obtained. Bulk Density was in the range of 74.72-78.57 kg/hl and was significantly higher in Maize 2. L/b ratio indicates grain shape, 1000 kernel weight reflects grain size and density whereas bulk density provides information on the packing ability of grains. The traits can be used for milling efficiency, grain filling, storage, handling and transportation.

Table 5: Physical analysis of maize

Sample	L/B ratio	1000 kernel wt (g)	Bulk Density (kg/hl)
Maize 1	1.18±0.08^{ab}	253.14±0.33^{a}	77.2±0.21^{a}
Maize 2	1.12±0.09^{a}	275.02±0.17^{b}	78.57±0.24^{b}
Maize 3	1.27±0.14^{b}	201.45±1.07^{c}	74.72±0.04^{c}

Note: Values are the mean ± standard deviation obtained from the triplicate data. Different alphabets in the same column indicate a significant difference ($p< 0.05$).

Two samples of Kodo Millet were received were subjected to physical analysis (1000 kernel weight, l/b ratio and bulk density) and chemical analysis (Moisture, Fat, Protein, Crude Fiber, Total Ash, Iron, Zinc, Phosphorus) (Table 6).

Table 6: Proximate analysis of Kodo Millet

Sample	Moisture %	Crude fat %	Crude protein	Crude fiber %	Total Ash %
KLE-	12.81±0.04^{a}	1.29±0.05^{a}	9.03±0.01^{a}	8.12±0.02^{a}	3.37±0.24^{a}
KLE-	12.71±0.03^{a}	0.99±0.01^{b}	8.94±0.12^{a}	9.82±0.15^{b}	3.4±0.09^{a}

Note: Values are the mean ± standard deviation obtained from the triplicate data. Different alphabets in the same column indicate a significant difference (p< 0.05). All data are in dry basis.

The proximate composition of kodo millet KLE-158 and KLE-159 is presented in Table 7. An independent samples t-test was conducted to compare parameters between two samples. There was a significant difference in crude fat [t(4)=11.23, p=0.0003] and crude fiber [t(4)=20.19, p=0.0004]. The result of proximate analysis aligns closely with the findings of Kt et al., 2021, who reported 10.90 % moisture content, 1.3% fat, 8.3% protein and 8.5% crude fiber in kodo millet flour.

Table 7: Minerals analysis of Kodo Millet

Sample	Phosphorus mg/100g	Irons mg/100g	Zinc mg/100g
KLE-158	277.04±2.08^{a}	2±0.11^{a}	5.46±0.04^{a}
KLE-159	314.78±23.96^{a}	2.64±0.58^{a}	6.95±0.33^{b}

Note: Values are the mean ± standard deviation obtained from the triplicate data. Different alphabets in the same column indicate significant difference (p< 0.05). All data are in dry basis.

The minerals content of kodo millet KLE-158 and KLE-159 is presented in table 6. An independent samples t-test was conducted to compare phosphorus. Iron and zinc between two samples. Zinc content was significantly higher in KLE-159 [t(4)=7.79, p=0.001]. Roopa et al., 2020 reported 378.65 mg/100g phosphorus, 3.55 mg/100 g iron and 2.08 mg/100g zinc in their paper. The phosphorus and iron content obtained in our analysis closely aligns with their findings, while the zinc content was observed to be slightly higher (Table 7). This could be attributed to factors such as varietal differences, soil composition, agricultural practices or post-harvest handling conditions, all of which are known to influence micronutrient levels in grains.

The physical properties of kodo millet KLE-158 and KLE-159 is presented in table 8. An independent samples t-test was conducted to compare the L/B ratio, 1000 Kernel weight, and Bulk density between two samples. 1000 kernel weight was significantly higher for KLE-156, whereas Bulk density was significantly higher for KLE-158 variety. L/b ratio indicates grain shape, 1000 kernel weight reflects grain size and density, whereas bulk density provides information on the packing ability of grains. The traits can be used for milling efficiency, grain filling, storage, handling, and transportation.

Table 8: Physical analysis of Kodo Millet

Sample	L/B Ratio	1000 Kernel weight (g)	Bulk Density (kg/hl)
KLE-158	1.12±0.08^{a}	2.77±0.02^{a}	67.25±0.03^{a}
KLE-159	1.1±0.06^{a}	3.91±0.04^{b}	64.74±0.04^{b}

Note: Values are the mean ± standard deviation obtained from the triplicate data. Different alphabets in the same column indicate significant difference (p< 0.05).

- **Legumes**

One sample of KBL-2 bean variety (code: NFRC/2407/06) from the Agriculture Research Station, Vijayanagar, Jumla, was analyzed for Proximate Composition, Minerals, polyphenols, and cooking loss (Table 9)**.** The Moisture (%), Fat (%), Crude fiber (%), Protein (%), and Ash (%) were found to be 10.61%, 1.19%, 7.45%, 3.23% and 3.67%., respectively. The moisture value falls within the recommended safe storage range for beans (≈9–12%); low moisture reduces fungal and mycotoxin risks and supports longer shelf life (Yahaya et al., 2022). Beans are naturally low-fat foods, typically ranging between 1–2% on a wet basis. This value aligns well with expected ranges. Low-fat enhances shelf stability (less prone to rancidity) (Alves et al., 2020). Iron (mg/100g), Calcium (mg/100g), and Phosphorous (mg/100g) were found to be 3.85, 87.2 and 518.07, respectively. Polyphenol (mg/100g) content and cooking loss (%) were found to be 390.43 and 9.35, respectively. The sample shows nutritional richness in fibre, minerals (phosphorus, calcium, iron), and polyphenols, making it beneficial for digestive health, mineral intake, and antioxidant protection (Rodríguez Madrera et al., 2023)

Table 9: Proximate, minerals, polyphenol, and cooking loss of bean

SN	Parameters	Bean (NFRC/2407/06)
1	Moisture (%)	10.61±0.09
2	Fat (%)	1.19±0.01
3	Crude fiber (%)	7.45±0.20
4	Protein (%)	3.23±0.25
5	Ash (%)	3.67±0.12
6	Iron (mg/100g)	3.85±0.75
7	Calcium (mg/100g)	87.2±3.54
8	Phosphorous (mg/100g)	518.07±2.01
9	Polyphenol (mg/100g)	390.43±24.26
10	Cooking loss	9.35±0.01

Note: Values expressed are mean ± standard deviation.

Three varieties of chickpeas and one mung variety from the National Legume Research Progamme, Khajura, Bake were analyzed for Proximate and Minerals (Table 10), which were significantly ($p < 0.05$) different among legume varieties. Moisture (%) was significantly ($p < 0.05$) high in KGP-59 and ICCV-97207, and protein content (%) was significantly ($p < 0.05$) high in ICCV-97207 and Mung panta-5. The moisture value falls within the range, as the value is supported by (Yahaya et al., 2022). Fat (%) was not significantly ($p > 0.05$) different. Ash (%) was significantly ($p < 0.05$) high in Mung bean, whereas Phosphorus (mg/100g) was significantly ($p < 0.05$) high in chickpeas. The higher the ash content wiill be reflected into higher concentrations of minerals, which are essential for energy metabolism (Nobile et al., 2013). But the results showed that a higher ash percentage does not necessarily mean that the concentration of all minerals will be higher, which might be affected by genetic, epigenetic, and abiotic factors. Similarly, Cude fibre (%) and Calcium (mg/100g) were significantly ($p < 0.05$) high in ICCX-840508-31 variety, but ICCV-

97207's iron concentration did not differ from it.. Iron content was found significantly (p< 0.05) high in the KPG-59 variety of chickpea, which is a strong source of iron among all cereal varieties (Hounsome et al., 2008).

Table 10: Proximate and Mineral analysis of chickpea and Mung.

SN	Parameters	KPG-59	ICCV-97207	ICCX-40508-	Mung panta-5
1	Moisture (%)	10.24±0.32[b]	10.97±0.06[a]	10.50±0.07[b]	10.46±0.16[b]
2	Protein (%)	20.57±0.52[b]	23.24±1.19[a]	18.79±0.6[c]	22.18±0.17[a]
3	Fat (%)	2.66±0.61[a]	2.53±0.39[a]	3.13±0.15[a]	1.52±1.74[a]
4	Ash (%)	2.49±0.04[b]	2.17±0.09[c]	2.55±0.15[b]	2.71±0.09[a]
5	Crude fibre (%)	11.11±0.35 [c]	12.10±0.24[b]	15.98±0.72[a]	7.56±0.04[d]
6	Iron (mg/100g)	6.23±0.8[a]	5.32±0.92[a]	6.21±0.29[a]	3.63±0.32[b]
7	Phosphorous	305.49±1.55[c]	281.92±4.58[d]	360.24±3.25[b]	479.68±12.17[a]
8	Calcium (mg/100g)	121.89±5.86[a]	121.90±24.12[a]	122.15±0.73[a]	82.54±1.27[b]

Note: Values expressed are mean ± standard deviation. Values with different letters in the superscripts in the same row differ significantly (p< 0.05).

- **Functional Flour (NFRC/2408/04)**

Fapar Flex is a sprouted buckwheat-based flour, which offers enhanced digestibility, bioactive compounds and potential antioxidant activity due to the sprouting process. The Performer is a composite flour blend of cocoa powder, banana powder, white musli and ashwagandha, combining energy-dense, antioxidant-rich and adaptogenic ingredients to support overall wellness. Pavitra Pitho is a multi-grain blend containing barley, wheat, sesame seeds, and buckwheat flour, designed to provide balanced nutrition with high fiber, essential minerals and bioactive compounds. Functional flours are gaining increasing attention due to their potential to improve health and provide nutritional benefits beyond basic macronutrients (Cardoso *et al.*, 2019). Three flour samples (Fapar Flex, Performer and Pavitra Pitho) were received from Kodali Ventures, Gothatar, each formulated with unique ingredient compositions targeting functional and nutritional properties. These were subjected to chemical analysis (Proximate analysis and antioxidant activity) (Table 11).

Table 11. Proximate and bioactives analysis of functional flour

Sample Name	Fapar Flex	The Performer	Pavitra Pitho
Moisture (%)	5.21±0.25	3.86±0.09	6.41±0.36
Fat (wb %)	0.87±0.13	2.64±0.02	7.31±0.16
Protein (wb %)	20.29±0.13	4.4±0.28	11.74±0.03
Fibre (wb%)	2.64±0.32	6.19±0.25	2.2±0.05
Ash (wb%)	8.17±0.32	1.76±0.02	4.43±0.01
Antioxidant (RSA %)	30.62±1.73	13.19±0.54	8.68±0.38

Among the samples, Pavitra Pitho exhibited the highest moisture content (6.41 ± 0.36%), followed by Fapar Flex (5.21 ± 0.25%), while The Performer showed the lowest value (3.86 ± 0.09%). This variation in moisture can be influenced by factors such as raw material characteristics and processing conditions and it plays a critical role in shelf life and product stability (Nasir *et al.*, 2003). Pavitra Pitho showed the highest fat content (7.31 ± 0.16%), followed by The Performer (2.64 ± 0.02%), whereas Fapar Flex had the lowest level (0.87 ± 0.13%). These variations are likely due to the differing amounts of fat-rich ingredients, including sesame seeds, cocoa powder and banana powder, present in each formulation. Fapar Flex showed the highest protein concentration (20.29 ± 0.13%), which can be attributed to the high protein content of sprouted buckwheat. Pavitra Pitho had moderate protein levels (11.74 ± 0.03%), while The Performer contained the least protein (4.4 ± 0.28%), likely due to the composition dominated by cocoa and banana powders.

The Performer had the highest fiber content (6.19 ± 0.25%), followed by Fapar Flex (2.64 ± 0.32%), and Pavitra Pitho showed the lowest (2.2 ± 0.05%). Fiber content is influenced by the type and proportion of cereals, seeds and plant-based ingredients in each formulation. Fapar Flex had the highest ash content (8.17 ± 0.32%), indicating a richer mineral composition, followed by Pavitra Pitho (4.43 ± 0.01%), while The Performer showed the lowest level (1.76 ± 0.02%). This variation reflects the presence of mineral-dense ingredients such as buckwheat and seeds in the respective formulations. The highest antioxidant activity was observed in Fapar Flex (30.62 ± 1.73%), followed by The Performer (13.19 ± 0.54%), while Pavitra Pitho showed the lowest (8.68 ± 0.38%). These differences may be due to the concentration of phenolics and other bioactive components, especially in ingredients like sprouted buckwheat and cocoa powder.

3.1.2 Chemical, nutritional, bioactive properties and antioxidant activity analysis of horticulture crops and spices.

- **Walnuts (Sample code: NFRC/2410/07)**

6 different varieties of walnuts from Horticulture Research Station, Rajikot, Jumla were analyzed for prozimate, flavonoid, polyphenol, and antioxidant activity (Table 12). Moisture (%) content ranged from 3.42-6.31 and was significantly high in Hade okhar, making it have lower storage stability. Protein (%) was significantly ($p < 0.05$) high in the Chinese variety. Also, this variety contains significantly ($p < 0.05$) high flavonoids and high polyphenols; best protein and polyphenol-rich variety**.** The polyphenol (mg/100g) of Payne is similar to the Chinese variety but had the significantly ($p < 0.05$) highest antioxidant activity (% Radical Scavenging Activity, RSA), which indicates that polyphenol content is the major contributor to antioxidant activity of walnut. Similarly, Nandram Lamcho variety had the highest fat (%).

Table 12: Proximate and bioactive contents of walnuts

S.N	Parameter	Payne	Hartley	Chinese	Nandram Lamcho	Nandram Golo	Hade Okhar
1	Moisture (%)	3.42±0.09 ^{c}	3.44±0.09 ^{c}	4.81±0.10 ^{b}	3.43±0.04 ^{c}	3.09±0.02 ^{d}	6.31±0.08 ^{a}
2	Protein (%)	16.80±0.07 ^{c}	17.30±0.30 ^{c}	23. ±0.05 ^{a}	10.98±0.62 ^{d}	11.43±0.06 ^{d}	19.07±0.51 ^{b}
3	Fat (%)	55.88±1.20 ^{a}	40.55±1.45 ^{b}	41.83±1.67 ^{b}	58.40±1.51 ^{a}	42.33±1.74 ^{b}	41.97±1.34 ^{b}
4	Flavonoid (mg/100g)	1079.66±38.71 ^{c}	845.38±20.76 ^{de}	1559.16±43.25 ^{b}	1754.22±44.55 ^{a}	996.36±6.21 ^{d}	775.95±10.31 ^{e}
5	Polyphenol (mg/100g)	2657.24±50.43 ^{a}	1348.82±4.38 ^{b}	2633.46±14.73 ^{a}	2265.56±12.97 ^{a}	1228.79±13.39 ^{c}	1373.92±10.44 ^{b}
6	Antioxidant (% RSA)	87.67±0.15 ^{a}	87.17±0.32 ^{a}	80.38±0.15 ^{bc}	78.56±0.88 ^{c}	84.66±0.98 ^{b}	84.37±0.41 ^{b}

Note: Values expressed are mean ± standard deviation.Values with different letters in the superscripts differ significantly ($p< 0.05$).

One walnut sample was received from the Temperate Horticulture Development Center, Marpha, Mustang. This was subjected to proximate and bioactive analysis (Table 13). Low moisture indicates safe storage and reduces the risk of rancidity, while fat content containing unsaturated fatty acids is beneficial for cardiovascular health. Protein content within the range (15-24%) contributes to essential amino acids intake and makes walnut a valuable plant protein (Pereira et al., 2008). High polyphenol compared to average walnut indicates strong antioxidant potential, showing that polyphenol-rich walnuts improve oxidative status and reduce inflammation (Pereira et al., 2008).

Table 13 : Proximate and bioactive content of walnut

S.N	Parameter	Walnut
1	Moisture (%)	3.56±0.07
2	Fat (%)	60.37±1
3	Protein (%)	17.88±0.16
4	Polyphenol (mg/100g)	4779.2±134.92
5	Flavonoid (mg/100g)	250.51±41.87
6	Antioxidant (%RSA)	70.77±4.36

Note: Values expressed are mean ± standard deviation.

- **Coffee**

28 germplasms from the National Coffee Research Program, Baletaksar, Gulmi were analyzed for different physiochemical properties (Table 14).

Table 14: Physicochemical analysis of coffee

Sample	Moisture content (%)	Water extract (%)	Caffeine (mg/100g)	Antioxidant (RSA%)	Polyphenol (mg/100g)	Tannin (mg/100g)
Arghakhanchi	2.67±0^{ab}	27.38±0.56^{j}	1.13±0.01^{hi}	95.26±0.11^{a}	6516.32±24.45^{c}	212.55±0.01^{m}
Bourbon	2.1±0.49^{ab}	34.59±0.55^{d}	1.42±0.04^{cd}	92±0^{efg}	5658.78±14.52^{h}	219.18±0.03^{j}
Catuai	2.02±0.07^{ab}	33.13±0.33^{f}	1.26±0^{ef}	68.46±0.66^{l}	4309.81±0.56^{q}	216.72±0.03^{l}
Catisic	0.6±0.07^{b}	22.39±0.07^{n}	1.25±0.01^{ef}	92.69±0de	6321.62±23.83^{e}	218.23±0.01^{k}
Chandragiri	2.09±0.05^{ab}	32.26±0.15^{g}	1.21±0.01^{fg}	93.84±0.06^{bc}	5904.69±3.42^{f}	219.21±0.01^{i}
chhetradip	1.84±0.66^{ab}	35.24±0.02^{c}	1.25±0.03^{ef}	93.49±1.32^{cd}	6907.48±10.89^{b}	209.76±0.06^{o}
Catimor	2.02±2.36^{ab}	26.59±0.06^{k}	1.62±0.03^{a}	91.18±0.19^{hi}	5481.99±6.25^{j}	218.62±0.03^{j}
Catura	2.06±0.39^{ab}	28.54±0.05^{i}	1±0.05^{k}	93.88±0.13^{bc}	5128.08±11.25^{l}	216.83±0.03^{k}
Gulmi Local	2.06±0.04^{ab}	23.84±0.09^{m}	1.25±0.02^{ef}	92.44±0.09^{def}	5410.11±8.69^{jk}	223.2±0.03^{c}
Hawaikona	2.42±0.18^{ab}	17.52±0.29^{q}	1±0^{k}	93.57±0^{cd}	5366.48±10.14^{k}	216.71±0.04^{l}
Hdy Catuari	1.14±0.13^{ab}	29.58±0.04^{h}	1.29±0^{e}	92.91±0.13^{cde}	5937.8±8.62^{f}	221.1±0.05^{e}
Indonesia	1±0.29^{ab}	27.49±0.26^{j}	1.42±0.03^{cd}	90.76±0.16^{i}	4946.71±7.37^{m}	218.29±0.02^{k}
Indotimtim	0.61±0.12^{b}	26.93±0.08^{jk}	1.66±0.02^{a}	89.8±0.5^{j}	6344.73±144.4^{1e}	223.02±0.02^{c}
Kaski Local	2.46±0.1^{ab}	41.25±0.39^{a}	1.2±0.01^{fg}	93.48±0.19^{cd}	5354.58±6.19^{k}	216.33±0.01^{l}
Mundonovo	1.75±0.02^{ab}	35.59±0.03^{c}	1.07±0.01^{ij}	83.74±0.14^{k}	6413.61±8.69^{d}	208.1±0.05^{p}
Obata	1.95±0.08^{ab}	24.82±0.2^{l}	1.3±0.01^{e}	91.73±0.09^{efg}	5757.61±8.64^{g}	221.61±0.02^{d}
Puranchour	2.54±0.23^{ab}	26.5±0.09^{k}	1.3±0.02^{e}	92.53±0.09^{def}	5795.31±10.3^{g}	220.27±0.69^{g}
Pacus	1.9±0.03^{ab}	34.39±0.22^{d}	1.21±0.04^{fg}	90.58±0.03^{i}	4746.66±7.4^{o}	219.04±0.05^{j}
Robusta	0.66±0.01^{b}	20.79±0.16^{o}	1.24±0^{ef}	91.84±0^{efg}	4557.95±1.75^{p}	224.47±0^{b}
Selection-10	2.49±0.24^{ab}	18.22±0.14^{p}	1.06±0.05^{g}	92.53±0.47^{def}	5467.67±4.56^{j}	220.01±0.02^{gh}
Solodin-12	0.86±0.02^{ab}	20.78±0.31^{o}	1.55±0.03^{b}	92.53±0.03^{def}	5568.69±14.79^{i}	219.8±0.13^{h}
Selection-8	1.34±0.11^{ab}	32.61±0.34^{fg}	1.4±0.06^{cd}	91.42±0.03^{fgh}	5479.57±9.98^{j}	226.04±0.11^{a}
Selection-9	2.73±0.05^{a}	21.05±0.25^{o}	1.21±0.01^{fg}	93.22±0.06^{cd}	5811.9±11.22^{g}	216.1±0.03^{m}
Sanramon	1.67±0.24^{ab}	29.61±0.37^{h}	1.46±0.01^{c}	92.52±0.11^{def}	7648.24±26.83^{a}	220.8±0.05^{f}
Syangja	1.24±0.35^{ab}	36.95±0.09^{b}	1.15±0^{gh}	94.75±0.34^{ab}	4570.91±7.37^{p}	218.24±0.02^{k}
Tekisic	2.39±0.17^{ab}	32.21±0.18^{g}	1.19±0^{fgh}	93.2±0.09^{cd}	4863.28±19.44^{n}	207.45±0.01^{q}
Woven	1.4±0.03^{ab}	24.09±0.13^{m}	1.13±0^{hi}	94.02±0.13^{bc}	5341.13±11.03^{k}	223.26±0.02^{c}
Yellow Katura	0.94±0.07^{ab}	33.68±0.32^{e}	1.37±0^{d}	66.43±0.59^{m}	5560.24±16.21^{i}	211.91±0.16^{n}

$^{a\text{-}q}$ Values with different letters in the superscripts differ significantly ($p < 0.05$). Values presented are means ± SD of triplicate values

The minimum and maximum moisture content were observed in Catistic (0.6±0.07%) and Selection-9 (2.73±0.05%), respectively. The moisture content in coffee ranges from 2%- 2.2% (Laukalja et al., 2022). The reason for low moisture content i.e. 0.6% may be due to over-roasting. Water activity is crucial for microbial stability. The minimum and maximum water activity content was observed in Hawaikona (17.52±0.2%**)** and Kaski local (41.25±0.39%**),** respectively. The water extract content in roasted coffee typically ranges between 2.3% and 8.8% (Baggenstoss et al., 2008). The method used for extracting water, such as prolonged soaking or heating at higher temperatures, can lead to higher water extraction rates. The minimum and maximum Caffeine content were observed in Hawaikona (1mg/100g) and Indotimtim

(1.66±0.02mg/100g), respectively. The caffeine content in roasted coffee ranges from 1.1 mg/100g to 2.5mg/100g (Alamri et al., 2022).

The minimum and maximum antioxidant activity was observed in Yellow katura catura (66.43±0.59%) and Arghakhanchi (95.26±0.11%). The antioxidant content ranges from 63% to 92% in roasted coffee (Liao et al., 2022). The minimum and maximum Polyphenol content was observed in Catuai amarilo-1 (4309.81±0.56 mg/100g) and Sanramon (7648.24±26.83 mg/100g). The polyphenol content ranges from 3600 mg/100g to 4300 mg/100g, depending upon the roasting type (Dybkowska et al., 2017). The minimum and maximum tannin content was observed in Tekisic (207.45±0.01mg/100g) and Selection-8 (226.04±0.11mg/100g) respectively. The tannin content in coffee ranges from 31.5 mg/100g to 516 mg/100g. Tannin content decreases sharply with an increase in roasting temperature of coffee (Cuong et al., 2014).

- **Ginger**

18 samples of ginger were received from the Coffee Research Programme, Baletaksar, Gulmi. The samples were subjected to test for its moisture, fat, crude fiber, and essential oil content (Table 15).

Table 15: Proximate analysis of ginger

Sample	Moisture (%)	Fat (%)	Crude Fiber (%)	Essential oil yield (%)
G1	$12.44±0.21^{ab}$	$2.71±0.242^{a}$	$8.44±0.16^{a}$	0.97
G2	$11.93±0.4^{a}$	$3.22±0.217^{a}$	$9.22±0.44^{ab}$	1.16
G3	$12.06±0.22^{a}$	$2.84±0.272^{a}$	$7.97±0.69^{a}$	0.99
G4	$11.9±0.31^{a}$	$2.79±0.051^{a}$	$7.82±0.46^{a}$	0.86
G5	$11.93±0.37^{a}$	$3.02±0.305^{a}$	$8.1±0.69^{a}$	0.80
G6	$13.36±0.3^{de}$	$2.54±0.135^{a}$	$7.67±0.27^{a}$	0.45
G7	$12.84±0.12^{bcd}$	$2.59±0.343^{a}$	$8.57±0.47^{a}$	0.44
G8	$12.55±0.09^{ab}$	$2.73±0.122^{a}$	$8.41±0.61^{a}$	0.77
G9	$12.46±0.25^{ab}$	$2.76±0.101^{a}$	$10.56±2.17^{a}$	0.83
G10	$12.49±0.45^{ab}$	$3.15±1.118^{a}$	$8.53±0.15^{a}$	0.64
G11	$12.09±0.13^{a}$	$3.13±0.456^{a}$	$8.27±0.15^{a}$	0.58
G12	$12.75±0.09^{bc}$	$3.47±0.29^{a}$	$9.75±1.21^{ab}$	0.58
G13	$13.27±0.19^{cde}$	$3.31±0.276^{a}$	$8.26±0.15^{a}$	0.61
G14	$12.53±0.13^{ab}$	$3.03±0.672^{a}$	$11.9±1.46^{c}$	0.52
G15	$12.54±0.17^{ab}$	$2.64±0.161^{a}$	$9.37±0.31^{ab}$	0.53
G16	$13.53±0.28^{e}$	$2.93±0.242^{a}$	$7.89±0.24^{a}$	0.54
G17	$12.83±0.08^{bcd}$	$2.99±0.08^{a}$	$8.33±0.08^{a}$	0.62
G18	$13.46±0.22^{e}$	$2.77±0.117^{a}$	$8.21±0.67^{a}$	0.54

Note: Values presented are means ± SD of triplicate value. $^{a-e}$ Values with different letters in the superscripts differ significantly ($p< 0.05$).

The statistical analysis showed the values of the moisture content of G-2, G-3, G-4, G-5, and G-11 differed significantly ($p< 0.05$) from all other ginger samples. The minimum and maximum moisture content were observed in G4 (11.9%) and G16 (13.53%), respectively. (Agu et al., 2016) reported 11% moisture content in dried ginger. The statistical analysis showed that there was no significant difference between (P>0.05) all the ginger samples. The minimum and maximum fat content was observed in G6 (2.54%) and G12 (3.47%), respectively. (Agu et al., 2016) reported 8.2% fat content in dried ginger. The statistical analysis showed the values of crude fiber content of G-1, G-3, G-4, G-5, G-6, G-7, G-8, G-9, G-10, G-11, G-13, G-16, G-17, and G-18 differed significantly (p< 0.05) from all other ginger sample. The minimum and maximum crude fiber content were observed in G6 (2.54%) and G12 (3.47%), respectively. (Agu et al., 2016) reported 11% crude fiber content in dried ginger. The minimum and maximum essential oil content in ginger were observed in G-7 (0.44%) and G-2 (1.16%), respectively.

Eight samples of Bose variety of ginger were received from National Commercial Crop Centre, Khumaltar, Lalitpur, which were subjected to oleoresin and crude fiber analysis (Table 16). The oleoresin content was in the range of 0.37-0.77%, whereas the crude fiber was found to be 1.11-1.93%. Oleoresin was significantly higher in T3 sample whereas crude fiber was significantly higher in T8 sample.

Table 16: Chemical analysis of ginger

SN	Oleoresin %	Crude fiber %
T1	0.4 ± 0.02^{a}	1.73 ± 0.01^{d}
T2	0.37 ± 0.01^{a}	1.11 ± 0.01^{a}
T3	0.77 ± 0.07^{d}	1.62 ± 0.08^{c}
T4	0.44 ± 0.02^{a}	1.69 ± 0.04^{cd}
T5	0.58 ± 0.03^{bc}	1.71 ± 0.01^{cd}
T6	0.59 ± 0.07^{bc}	1.79 ± 0.07^{d}
T7	0.51 ± 0.01^{b}	1.34 ± 0^{b}
T8	0.63 ± 0.01^{c}	1.93 ± 0.07^{e}

Note: Values are the mean ± standard deviation obtained from the triplicate data. Different alphabets in the same column indicate a significant difference (p< 0.05). All data are on wet basis.

- **Turmeric**

Two samples of turmeric were received from Agro Ilam Pvt. Ltd, which were subjected to curcumin analysis (Table 17). The curcumin content was found to be 3.89-4.3 mg/100g. Turmeric 1 was found to be significantly higher than Turmeric 2. Devkota and Neupane, (2025) has reported 2.81-6.07% curcumin content in turmeric. Various factors like variety, geographic origin and processing affects the curcumin content of turmeric. These results can guide cultivar selection, encourage value-added processing, and contribute to increasing farmers’ income through quality-focused production.

Table 17: Curcumin content of turmeric

Sample	Curcumin content (mg/100g)
Turmeric 1	4.3±0.01a
Turmeric 2	3.89±0.01b

Note: Values are the mean ± standard deviation obtained from the triplicate data. Different alphabets in the same column indicate significant difference ($p < 0.05$). Data is in dry basis.

3.1.3. Proximate, minerals, and Texture Profile Analysis of meat, dairy and fish products

- **Proximate and mineral determination of cheese**

10 cheese samples were received from the National Goat Research Program. The samples were subjected to analysis for their moisture, fat, protein, iron, calcium, and texture (Table 18).

Table 18: Proximate and mineral analysis of cheese

sample	Moisture	Fat (%)	Protein (%)	Iron	Calcium
Cheese-1	$39.45±0.22^{b}$	$20.34±2.74^{abc}$	$33.13±2.96^{c}$	$1.81±0.16^{c}$	$98.43±1.96^{a}$
Cheese-2	$30.94±1.77^{a}$	$24.05±0^{bcd}$	$36.54±0.78^{cd}$	$2.15±0.11^{d}$	$110.88±2.05^{a}$
Cheese-3	$38.21±2.55^{b}$	$26.22±1.45^{cd}$	$38.81±0.67^{de}$	$1.15±0.09^{ab}$	$81.94±2.19^{a}$
Cheese-4	$35.54±2.61^{b}$	$23.35±4.66^{bcd}$	$41.72±2.05^{e}$	$1.26±0.11^{b}$	$96.21±0.57^{a}$
Cheese-5	$45.58±0.15^{c}$	$21.52±2.52^{abc}$	$25.52±0.61^{b}$	$1.34±0.05^{b}$	$101.27±8.06^{a}$
Cheese-6	$54.57±0.26^{d}$	$16.11±0.36^{a}$	$20.56±1.92^{a}$	$0.91±0.11^{a}$	$490.74±583.98^{a}$
Cheese-7	$56.46±0.62^{d}$	$18.94±0.13^{abc}$	$20.8±0.67^{a}$	$1.34±0.07^{b}$	$66.87±1.91^{a}$
Cheese-8	$61.58±3.94^{e}$	$16.71±1.42^{ab}$	$18.67±1.77^{a}$	$1.86±0.14^{c}$	$70.6±8.8^{a}$
Cheese-9	$29.2±1.01^{a}$	$29.42±0.58^{d}$	$33.56±0.51^{c}$	$3.27±0.18^{f}$	$127.26±2.19^{a}$
Cheese-10	$40.54±1.88^{d}$	$24.02±1.54^{bcd}$	$28.33±1.06^{b}$	$2.49±0.11^{e}$	$107.62±3.81^{a}$

Note: Values presented are means ± SD of triplicate values .$^{a-f}$ Values with different letters in the superscripts differ significantly ($p < 0.05$).

The statistical analysis showed the values of the moisture content of cheese-2 and cheese-9 differed significantly ($p < 0.05$) from other cheese sample. The minimum and maximum moisture were observed in cheese-9 (29.2%) and cheese-7 (56.46%), respectively. Park, (1991) reported the moisture content range for goat cheese is roughly from about 27% in hard goat cheeses up to about 65% in soft or flavored varieties. The statistical analysis showed the value of fat content of cheese-1, cheese-5 and cheese-7 differed significantly ($p < 0.05$) from other cheese sample. The minimum and maximum fat content were observed in cheese-8 (16.71%) and cheese-9 (29.42%) respectively. Fat content values in various goat cheeses often fall within 30–45%, but specific values can fluctuate based on regional production and cheese type (Paszczyk & Łuczyńska, 2020). The statistical analysis showed the value of protein content of cheese-6, cheese-7, and cheese-8 differed significantly ($p < 0.05$) from other cheese sample. The minimum and maximum protein content was observed in cheese-8 (18.67%) and cheese-4 (41.72%) respectively. Goat cheeses typically have protein content within a broader range from about 15% to 25% depending on type, processing, and aging, with soft goat cheeses generally having slightly lower protein and harder cheeses having higher protein content (Park et al., 2017).

The statistical analysis showed the value of iron content of cheese-6 differed significantly ($p < 0.05$) from other cheese samples. The minimum and maximum iron content was observed in cheese-6 (0.91 mg/100g) and cheese-9 (3.27 mg/100g), respectively. Iron content in fresh goat cheese is reported around 0.05 mg to 0.07 mg per 100 g of cheese (Mirzaei & Chaleshtori, 2022). The statistical analysis showed that there is no significant difference ($P>0.05$) between all cheese samples. The minimum and maximum calcium content was observed in cheese-7 (66.87 mg/100g) and cheese-9 (127.26 mg/100g), respectively. Pawlos et al., (2022) study found that calcium content in fresh acid rennet goat cheese in the range of 120.83 mg to 151.21 mg/100g, with calcium content increasing significantly upon addition of calcium citrate during milk processing.

- Texture Profile Analysis (TPA) of cheese

The TPA analysis of the same samples were done (Table 19)

Table 19: Texture Analysis of Cheese

Sample	Hardness	Adhesiveness	Resilience	Cohesion	springiness	Gumminess	Chewiness
Cheese-1	37.67 ± 2.45^{d}	-0.47 ± 0.09^{b}	3.72 ± 0.27^{a}	0.17 ± 0.01^{a}	32.95 ± 3.1^{a}	6.57 ± 0.74^{b}	2.17 ± 0.39^{a}
Cheese-2	36.72 ± 2.45^{d}	-0.43 ± 0.09^{b}	3.63 ± 0.2^{a}	0.17 ± 0.01^{a}	33.45 ± 7.21^{a}	6.3 ± 0.41^{b}	33.45 ± 7.21^{a}
Cheese-3	32.36 ± 2.35^{c}	$-0.12\pm0.03c^{d}$	6.75 ± 0.87^{cd}	0.21 ± 0.02^{b}	39.35 ± 6.08^{ab}	6.9 ± 0.92^{b}	39.35 ± 6.08^{a}
Cheese-4	34.04 ± 2.68^{cd}	-0.21 ± 0.03^{c}	6.21 ± 0.78^{c}	0.24 ± 0.02^{bcd}	47.84 ± 9.31^{bc}	8.11 ± 0.46^{b}	47.84 ± 9.31^{a}
Cheese-5	15.01 ± 2.82^{b}	-0.13 ± 0.02^{cd}	7.27 ± 0.38^{de}	0.23 ± 0.01^{bc}	67.98 ± 6.04^{de}	3.41 ± 0.67^{a}	67.98 ± 6.04^{a}
Cheese-5	43.25 ± 3.78^{e}	0.01 ± 0^{d}	11.66 ± 0.45^{h}	0.28 ± 0.02^{ef}	77.87 ± 9.46^{ef}	12.2 ± 1.57^{c}	77.87 ± 9.46^{c}
Cheese-6	17.17 ± 2.1^{b}	-0.25 ± 0.03^{c}	5.79 ± 0.47^{bc}	0.23 ± 0.01^{bc}	73.45 ± 6.55^{def}	3.95 ± 0.5^{a}	73.45 ± 6.55^{a}
Cheese-6	11.26 ± 0.97^{a}	-0.17 ± 0.03^{c}	5.85 ± 0.42^{bc}	0.24 ± 0.01^{bcd}	68.46 ± 7.78^{de}	2.67 ± 0.19^{a}	68.46 ± 7.78^{a}
Cheese-7	9.36 ± 0.89^{a}	-0.41 ± 0.06^{b}	7.33 ± 1.04^{de}	0.26 ± 0.04^{cde}	64.31 ± 8.72^{d}	2.45 ± 0.5^{a}	64.31 ± 8.72^{a}
Cheese -8	17.52 ± 1.75^{b}	-0.53 ± 0.06^{b}	5.04 ± 0.19^{b}	0.21 ± 0.01^{b}	77.15 ± 6.36^{ef}	3.68 ± 0.38^{a}	77.15 ± 6.36^{a}
Cheese-9	56.51 ± 3.39^{f}	-0.02 ± 0^{d}	8.08 ± 0.97^{e}	0.24 ± 0.02^{bcd}	46.08 ± 7.55^{bc}	13.78 ± 1.39^{c}	46.08 ± 7.55^{b}
Cheese-9	122.07 ± 4.37^{g}	-0.02 ± 0.01^{d}	10.12 ± 0.73^{g}	0.27 ± 0.03^{def}	72.76 ± 7.4^{def}	33.15 ± 3.91^{b}	72.76 ± 7.4^{d}
Cheese-10	38.04 ± 2.44^{d}	-1.39 ± 0.29^{a}	3.52 ± 0.2^{a}	0.17 ± 0.01^{a}	52.58 ± 6.99^{c}	6.57 ± 0.33^{b}	52.58 ± 6.99^{a}
Cheese-10	135.33 ± 4.71^{h}	0.02 ± 0^{d}	9.08 ± 0.72^{f}	0.3 ± 0.03^{f}	83.1 ± 4.47^{f}	40.16 ± 4.28^{e}	83.1 ± 4.47^{e}

Note: Values presented are means ± SD of triplicate values. $^{a\text{-}h}$ values with different letters in the superscripts differ significantly ($p < 0.05$).

- *Hardness*

The statistical analysis showed that the hardness of cheese-6 outer and cheese-7 differed significantly ($p < 0.05$) from other cheese samples. The minimum and maximum hardness were observed in cheese-7 (9.36) and cheese-10 outer (135.33), respectively.

- *Adhesiveness*

The statistical analysis showed that the adhesiveness of cheese-10 inner differed significantly ($p < 0.05$) from other cheese samples. The minimum and maximum adhesiveness was observed in cheese-10 inner (-1.39) and cheese- 5 outer (-0.01), respectively.

- *Resilience*

The statistical analysis showed that the resilience of cheese-1, cheese-2 and cheese-10 inner differed significantly ($p < 0.05$) from other cheese samples. The minimum and maximum resilience were observed in cheese-10 inner (3.52) and cheese- 5 outer (11.66), respectively.

- *Cohesion*

The statistical analysis showed that the cohesion of cheese-1, cheese-2 and cheese-10 inner differed significantly ($p < 0.05$) from other cheese samples. The minimum and maximum cohesion was observed in cheese-1, cheese-2 & cheese-10 inner (0.17) and cheese-10 outer (0.3), respectively.

- *Springiness*

The statistical analysis showed that the springiness of cheese-1 and cheese-2 differed significantly ($p < 0.05$) from other cheese samples. The minimum and maximum springiness was observed in cheese-1 (32.95) and cheese-10 outer (83.1), respectively.

- *Gumminess*

The statistical analysis showed that the gumminess of cheese-5 inner, cheese-6 inner, cheese-6 outer, cheese-7 and cheese-8 differed significantly ($p < 0.05$) from other cheese samples. The minimum and maximum gumminess was observed in cheese-7 (2.45) and cheese-10 outer (40.16) respectively.

- *Chewiness*

The statistical analysis showed that the chewiness of cheese-1, cheese-2, cheese-3, cheese-4, cheese-5 inner, cheese-6 inner, cheese-7, cheese-8 and cheese-10 inner differed significantly ($p < 0.05$) from other cheese samples. The minimum and maximum chewiness was observed in cheese-1 (2.17) and cheese-10 outer (83.1) respectively.

- **Fish Sauce (Sample Code: NFRC-2502-02)**

3 sample of fish sauce were received from the National Fishery Research Centre, Godawari, Lalitpur and proximate and salt were analyzed (Table 20). No significance ($p < 0.05$) difference was found except for Fish sauce 3. It has a comparatively high fat% and low Salt% than other samples, since fish sauce is not a fat-rich product because it gets removed during fermentation and processing. Ash content reflects high minerals and salt content. Nitrogen% and Protein% values indicate good fermentation quality, since protein nitrogen is derived from hydrolyzed fish proteins (amino acids, peptides). Fish sauce 1 and 2 have higher salt (>5.7%), improving preservation, while Fish sauce 3 has lower salt (5.02%), potentially more prone to microbial spoilage but less salty taste. The Moisture% was found to be high, and all the other parameters were generally low while comparing the result with Mueda (2015) due to a change in fermentation time.

Table 20: Proximate and salt analysis of fish sauce

S.N	Parameter	Fish sauce 1	Fish sauce 2	Fish sauce 3
1	Moisture (%)	74.12±0.15 ^{a}	73.01±1.09 ^{a}	73.38±0.94 ^{a}
2	Fat (%)	0.07±0.01 ^{b}	0.05±0.01 ^{b}	0.14±0.02 ^{a}
3	Ash(%)	20.25±0.12 ^{a}	21.14±0.07 ^{a}	20.33±1.30 ^{a}
4	Nitrogen (%)	0.64±0.01 ^{a}	0.67±0.02 ^{a}	0.64±0.02 ^{a}
5	Protein (%)	4±0.08 ^{a}	4.19±0.10 ^{a}	3.99±0.10 ^{a}
6	Salt(%) as NaCl	5.80±0.04 ^{a}	5.72±0.02 ^{a}	5.02±0.09 ^{b}

Note: Values expressed are mean ± standard deviation. Values with different letters in the superscripts differ significantly ($p < 0.05$).

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3.2. Exploring genetic diversity, breeding and good management practices, processing, value addition and geographical indication indicators of large cardamom

Large cardamom (*Amomum subulatum*) is a perennial herbaceous plant from the *Zingiberaceae* family, is widely known as "Black Gold" or "Brown Gold" and locally known in Nepal as "*Kholsa ko Sun*." It grows in shaded, moist areas such as forest floors, near streams and marginal lands. This spice crop can grow between 1.5 to 2.5 meters tall, flourishing at altitudes of 765-1675m above the sea level. Large cardamom is highly climate-dependent, with optimal growth occurring in temperatures of 4-20℃, annual rainfall of 2000-2500 mm and humidity levels exceeding 90% (Fadlalla and Elsheikh, 2016). Cardamom is known for its enchanting aroma, multifaceted flavor, and extensive applications in culinary creations and traditional remedies. It is among the three most expensive spices, alongside saffron and vanilla. Cardamom is widely used in perfumes and the food industry, where it adds depth to meats, baked goods, soups, fruit dishes, jellies and pickles. Its aroma is often described as a mix of sweet, citrusy, floral, warm and minty tones (Abdullah et al., 2022).

Five fresh samples of large cardamom varieties: Jhirmale, Golsai, Ramsai, Dambarsai and Bharlange, together with thirteen dried samples, were collected from Dhankuta, Pakhribash, Sankhuwasabha and Tehrathum districts. The fresh samples were subjected to three different drying methods: hybrid solar drying (Dried for 2 days), freeze drying (Pre-freezing: -60^{o}Cto -80^{o}C vacuum: 1 Pa, Condenser: -50˚c to -80˚, Drying: 20-24 hour) and cabinet drying (60˚C for 24 hours) (Table 21). Fifteen different samples, thus prepared based on the different drying methods for five varieties and 13 dried samples were subjected to different physiochemical analyses.

3.2.1 Drying Yield

Table 21: Drying Yield of Large Cardamom Sample

Varieties	Yield (%) for drying methods			
	Freeze Dried	Cabinet Dried	Hybrid Solar	Overall
Jirmale	$77.77{\pm}0.01^{dx}$	$80.15{\pm}0.03^{dy}$	$76.62{\pm}0.02^{dz}$	$78.18{\pm}1.55^{d}$
Golsai	$77.41{\pm}0.01^{cx}$	$78.97{\pm}0.02^{cy}$	$75.22{\pm}0.02^{cz}$	$77.20{\pm}1.63^{c}$
Ramsai	$76.46{\pm}0.02^{ax}$	$77.02{\pm}0.02^{ay}$	$73.52{\pm}0.02^{az}$	$75.67{\pm}1.63^{a}$
Dambarsai	$76.54{\pm}0.03^{bx}$	$78.06{\pm}0.03^{by}$	$74.22{\pm}0.02^{bz}$	$76.27{\pm}1.67^{b}$
Bharlangey	$81.02{\pm}0.01^{ex}$	$80.02{\pm}0.02^{ey}$	$80.17{\pm}0.02^{ez}$	$80.40{\pm}0.46^{e}$
Overall	$77.84{\pm}1.72^{b}$	$78.84{\pm}1.22^{c}$	$75.95{\pm}2.43^{a}$	

Note: Values expressed are mean ± standard deviation. Means in the row and column with different superscripts are significantly at $p < 0.05$.

The statistical analysis showed significant differences ($p < 0.05$) in yield (%) among the cardamom varieties and drying methods. The minimum yield was observed in Ramsai under hybrid solar drying (73.52 ± 0.02%), while the maximum yield was observed in Bharlangey under freeze drying (81.02 ± 0.01%). Overall, Bharlangey showed the highest yield among the varieties, whereas Ramsai showed the lowest. The overall yield across all samples ranged from 73% to 81%. The difference in yield percentage can be explained by several determinants including the efficiency of the drying method, the initial moisture content of the raw material, varietal differences, post-harvest handling practices, geographical conditions and packaging and storage conditions (Shrestha et al., 2018).

3.2.2. Length and Thickness

Table 22: Length and Thickness of Large Cardamom

Sample Name	Length (mm)	Thickness (mm)
Jhirmale Fresh	23.67 ± 2.42^{defg}	16.27 ± 2.15^{a}
Golsai Fresh	23.17 ± 1.56^{efg}	14.98 ± 2.37^{abcd}
Ramsai Fresh	25.74 ± 3.21^{bcde}	15.18 ± 1.4^{abc}
Dambarsai Fresh	22.56 ± 1.37^{fg}	13.98 ± 2.56^{bcde}
Bharlangey Fresh	28.37 ± 2.28^{ab}	15.8 ± 1.68^{ab}
Jhirmale CD	23.31 ± 1.97^{efg}	12.64 ± 2.08^{def}
Golsai CD	21.85 ± 1.58^{fg}	8.58 ± 1.04^{h}
Ramsai CD	26.47 ± 1.61^{abcd}	11.29 ± 2.47^{fg}
Dambarsai CD	22.12 ± 2.27^{fg}	12.59 ± 1.23^{def}
Bharlangey CD	28.59 ± 3.14^{ab}	13.68 ± 1.34^{bcdef}
Jhirmale HD	22.01 ± 2.57^{fg}	13.04 ± 2^{cdef}
Golsai HD	22.42 ± 1.54^{fg}	8.63 ± 1.17^{h}
Ramsai HD	27.15 ± 3.36^{abc}	13.01 ± 1.93^{cdef}
Dambarsai HD	22.58 ± 1.21^{fg}	10.37 ± 0.97^{gh}
Bharlangey HD	29.36 ± 3.69^{a}	12.89 ± 1.01^{cdef}
Jhirmale FD	25.03 ± 2.56^{cdef}	12.8 ± 1.05^{cdef}
Golsai FD	21.13 ± 0.85^{g}	11.89 ± 1.49^{efg}
Ramsai FD	28.5 ± 2.1^{ab}	12.82 ± 1.06^{cdef}
Dambarsai FD	23.88 ± 2.19^{defg}	12.62 ± 1.53^{def}
Bharlangey FD	27.55 ± 2.15^{abc}	14.11 ± 2.23^{bcde}

Note: FD- Freeze Dried CD- Cabinet Dried HD- Hybrid Dried. Values with different letters in the superscripts differ significantly ($p<0.05$). Values presented are means ± SD of triplicate values.

When the capsule length and thickness of large cardamom was analyzed statistically, significant differences were observed among the fresh, cabinet-dried, hybrid-dried and freeze-dried samples ($p < 0.05$). The highest capsule length was observed in Bharlangey under hybrid drying (29.36 ± 3.69 mm), whereas the lowest length was recorded in Golsai under freeze drying (21.13 ± 0.85 mm). In terms of capsule thickness, the maximum value was found in fresh Jhirmale (16.27 ± 2.15 mm), while the minimum thickness occurred in Cabinet-dried Golsai (8.58 ± 1.04 mm). The variations in dimensions can be due to the impact of drying methods on structural integrity, the rate of moisture loss, and natural variation among the samples (Khura et al., 2013). Freeze drying, in particular, is known to better preserve cellular integrity compared to other drying methods, resulting in less shrinkage and, consequently, a thicker appearance which is confirmed through this analysis.

3.2.3 Analysis of Large Cardamom

Table 23: Analysis of Large Cardamom Sample

Sample	Essential oil (db %)	MC (wb%) Seed	MC (wb%) Peel
Freeze dried Jirmale	2.71 ± 0.01^{n}	7.89 ± 0.27^{k}	6.5 ± 0.42^{cd}
Freeze dried Golsai	3.12 ± 0.02^{jk}	9.56 ± 0.64^{i}	7.28 ± 0.22^{bcd}
Freeze dried Ramsai	4.97 ± 0.01^{d}	8.58 ± 0.14^{j}	7.68 ± 0.33^{abcd}
Freeze dried Dambarsai	4.12 ± 0.02^{g}	8.45 ± 0.23^{jk}	8.11 ± 0.53^{abcd}
Freeze dried Bharlangey	5.58 ± 0.01^{a}	8.17 ± 0.08^{jk}	9.8 ± 5.24^{ab}
Cabinet dried Jirmale	1.77 ± 0.02^{q}	4.84 ± 0.46^{m}	5.36 ± 0.43^{d}
Cabinet dried Golsai	3.20 ± 0.01^{j}	5.07 ± 0.12^{m}	5.69 ± 0.15^{d}
Cabinet dried Ramsai	2.34 ± 0.02^{p}	5.98 ± 0.24^{l}	6.47 ± 0.28^{cd}
Cabinet dried Dambarsai	3.81 ± 0.01^{h}	4.83 ± 0.15^{m}	5.5 ± 0.38^{d}
Cabinet dried Bharlangey	5.36 ± 0.01^{b}	8.02 ± 0.14^{jk}	2.95 ± 0.04^{e}
Hybrid dried Jirmale	3.11 ± 0.01^{jk}	13.22 ± 0.36^{c}	7.4 ± 0.11^{abcd}
Hybrid dried Golsai	2.86 ± 0.01^{m}	18.69 ± 0.13^{a}	8.89 ± 0.15^{abc}
Hybrid dried Ramsai	3.56 ± 0.02^{i}	12.36 ± 0.42^{de}	7.82 ± 0.62^{abcd}
Hybrid dried Dambarsai	1.77 ± 0.01^{q}	11.78 ± 0.09^{ef}	6.46 ± 0.09^{cd}
Hybrid dried Bharlangey	3.75 ± 0.01^{h}	13.95 ± 0.41^{b}	7.07 ± 0.08^{bcd}
Local bhatti 1	2.96 ± 0.05^{l}	10.64 ± 0.8^{h}	9.55 ± 0.26^{abc}
Local bhatti 2	2.56 ± 0.05^{o}	10.59 ± 0.18^{h}	7.62 ± 0.27^{abcd}
Local bhatti 3	3.03 ± 0.05^{kl}	12.7 ± 0.11^{d}	9.81 ± 0.15^{ab}
Smokeless bhatti 1	2.73 ± 0.05^{n}	10.79 ± 0.15^{h}	7.23 ± 0.06^{bcd}
Smokeless bhatti 2	3.1 ± 0.10^{jk}	11.55 ± 0.04^{fg}	7.66 ± 0.22^{abcd}
Smokeless bhatti 3	2.7 ± 0.11^{n}	13.7 ± 0.34^{b}	10.36 ± 0.05^{a}
Smokeless bhatti 4	2.83 ± 0.05^{m}	11.8 ± 0.09^{ef}	9.53 ± 0.05^{abc}
Cabinet dried Farmer	3.03 ± 0.05^{kl}	10.99 ± 0.07^{gh}	7.72 ± 0.03^{abcd}
Solar dried Farmer	3.2 ± 0.1^{j}	11.43 ± 0.19^{fg}	7.23 ± 0.14^{bcd}
Oven dried Farmer	3.2 ± 0.1^{j}	9.91 ± 0.05^{i}	8.18 ± 0.1^{abcd}
Local Bhatti Farmer 1	4.5 ± 0.0^{e}	11.9 ± 0.28^{ef}	10.1 ± 0.38^{ab}
Local Bhatti Farmer 2	4.21 ± 0.01^{f}	12.13 ± 0.26^{def}	10.12 ± 0.69^{ab}
Local Bhatti Farmer 3	5.2 ± 0.01^{c}	10.68 ± 0.13^{h}	9.48 ± 0.05^{abc}

Note: Values presented are means ± SD of triplicate values. Values with different letters in the superscripts differ significantly ($p<0.05$).

- **Essential Oils**

The statistical analysis showed that the essential oil content of large cardamom varied significantly ($p < 0.05$) with different drying methods (Table 23). Among the laboratory-scale methods, freeze drying retained the highest oil content (2.71% - 5.58%), whereas cabinet drying showed the lowest (1.77% - 5.36%). In farmer-level traditional methods, local bhatti samples showed high essential oil contents (2.56% - 5.20%), while smokeless bhatti samples showed slightly lower values (2.70% - 3.10%). Overall, the highest essential oil content was obtained in freeze-dried samples (5.58%), while the lowest was observed in cabinet and hybrid dried samples (1.77%). The difference in essential oil content among dried large cardamom samples can be attributed to several factors, including drying conditions, the volatility of essential oils, chemical composition variability, drying rate effects and storage conditions (Wang et al., 2021).

- **Moisture Content**

The moisture content of large cardamom seeds ranged from 4.83 to 18.69%, while the peel exhibited a range of 2.95 ± 10.36% (Table 23). The highest seed moisture content was recorded in the Golsai variety subjected to hybrid drying (18.69 ± 0.13%), whereas the lowest was observed in Dambarsai under cabinet drying (4.83 ± 0.15%). In the peel, the maximum moisture was observed in Smokeless Bhatti 3 (10.36 ± 0.05%), and the minimum in Bharlangey under cabinet drying (2.95 ± 0.04%). Variations in moisture content are likely influenced by factors such as drying temperature and duration, sample size and surface area, processing conditions including ambient humidity during drying, as well as subsequent ‘ and storage (Rao et al., 2001).

- **Volatile Compounds**

A total of sixteen volatile compounds were identified in large cardamom, including β-Thujene, α-Pinene, 4(10)-Thujene, Sabinene, (–)-β-Pinene, β-Myrcene, α-Terpinene, 1,8-Cineole, γ-Terpinene, δ-Terpineol, Terpinen-4-ol, α-Terpineol, Germacrene D, β-Selinene,trans-Nerolidol,Longifolenaldehyde,and(E)-15,16-Dinorlabda-8(17),11-dien-13-one. The results of volatile compound analysis are presented in four separate tables for clarity. Table 23 contains the volatile composition of hybrid-dried samples. Table 24 presents the volatile composition of freeze-dried and cabinet-dried samples from the five large cardamom varieties, namely Jhirmale, Golsai, Ramsai, Dambarsai, and Bharlangey and also Local Bhatti 1. Table 25 includes the volatile composition of samples processed using traditional local bhatti and smokeless bhatti drying methods. Table 26 shows the volatile composition of farmer-processed samples obtained through solar drying, cabinet drying, oven drying, and local bhatti methods. Statistical analysis of the volatile compounds was performed using one-way ANOVA to determine significant differences among the drying methods, with results indicating which compounds varied significantly ($p < 0.05$) depending on the drying technique applied.

Table 24: The volatile composition of hybrid-dried samples

Compounds	Jhirmale	Golsai HD	Ramsai HD	Dambarsai	Bharlange
β-Thujene	0.86±0^{h}	0.81±0.01^{i}	0.92±0.02^{g}	0±0^{j}	0±0^{j}
α-Pinene	6.61±0.17^{h}	6.71±0.1^{h}	6.77±0.07^{h}	3.66±0.13^{j}	4.71±0.12^{i}
4(10)-Thujene/	5.01±0.06^{b}	4.42±0.24^{ef}	4.93±0.12^{bc}	2.01±0.03^{j}	2.83±0.09^{h}
(-)-β-Pinene	7.48±0.2^{f}	7.61±0.19^{ef}	7.96±0.07^{bc}	5.05±0.16^{i}	6.13±0.12^{g}
β-Myrcene	2.76±0.03^{g}	2.64±0.05^{hi}	2.74±0.05^{g}	0.93±0.01^{n}	1.34±0.05^{k}
α-Terpinene	0.66±0.03^{e}	0.95±0.04^{c}	0.96±0.05^{c}	1.09±0.16^{b}	0±0^{f}
1,8-Cineole	51.32±0.13	53.5±1.69^{e}	51.53±0.62^{f}	49.25±0.2^{g}	73.57±0.9^{a}
γ-Terpinene	1.03±0.03^{k}	1.46±0.08^{ef}	1.38±0.06^{ghi}	1.64±0.11^{d}	0±0^{m}
δ-Terpineol	2.09±0.07^{bc}	1.95±0.04^{ef}	2.03±0.04^{cd}	3.01±0.08^{a}	0.88±0.04^{j}
Terpinen-4-ol	2.82±0.06^{j}	3.68±0.2^{fg}	3.54±0.06^{gh}	4.3±0.08^{a}	1.08±0.05^{k}
α-Terpineol	9.64±0.11^{bc}	9.34±0.15^{ef}	9.42±0.11^{cd}	13.42±0.23	5.69±0.23^{j}
Germacrene D	0.68±0.03^{k}	0.85±0.06^{i}	0.87±0.02^{hi}	1.58±0.02^{a}	0±0
β-Selinene	0.64±0.04^{k}	0.74±0.01^{ij}	0.75±0.03^{ij}	1.5±0.08^{d}	0.86±0.06^{g}
trans-Nerolidol	3.47±0.09^{i}	3.63±0.22^{hi}	3.94±0.11^{f}	6.29±0.14^{a}	1.92±0.1^{h}
Longifolenaldehy	1.5±0.06^{b}	1.24±0.23^{c}	0.94±0.03^{fe}	2.37±0.05^{a}	0±0
(E)-15,16-Dinorlabda-	0.85±0.06^{cd}	0±0	0.55±0.02^{g}	1.46±0.07^{a}	0±0

Note: Values presented are means ± SD of triplicate values. Values with different letters in the superscripts differ significantly ($p<0.05$).

Table 25: The volatile composition of freeze-dried and cabinet-dried and local Bhatti samples

Compounds	Jhirmale FD	Golsai FD (%)	Ramsai CD (%)	Dambarsai CD	Bharlangey CD	Local bhatti 1
β-Thujene	0 ± 0^{j}	0.83 ± 0^{hi}	0.97 ± 0.01^{f}	0 ± 0^{j}	1.1 ± 0.02^{cde}	1.26 ± 0.07^{a}
α-Pinene	3.74 ± 0.06^{j}	6.72 ± 0.07^{h}	7.07 ± 0.11^{g}	4.52 ± 0.01^{i}	7.45 ± 0.04^{cdef}	7.79 ± 0.03^{a}
4(10)-Thujene/	1.86 ± 0.04^{j}	4.6 ± 0.05^{de}	4.58 ± 0.13^{de}	2.25 ± 0.04^{i}	5.39 ± 0.06^{a}	4.96 ± 0.07^{bc}
(-)-β-Pinene	5.6 ± 0.06^{h}	7.73 ± 0.11^{def}	8.05 ± 0.11^{bcd}	6.33 ± 0.19^{g}	8.34 ± 0.06^{ab}	8.51 ± 0.06^{a}
β-Myrcene	1.04 ± 0.03^{m}	2.57 ± 0.04^{i}	2.79 ± 0.06^{fg}	1.23 ± 0.02^{l}	2.92 ± 0.03^{e}	3.26 ± 0.05^{b}
α-Terpinene	0.84 ± 0.01^{d}	0.88 ± 0.04^{cd}	1.08 ± 0.07^{b}	0 ± 0^{f}	0.98 ± 0^{c}	1.14 ± 0.06^{ab}
1,8-Cineole	65.89 ± 0.4^{b}	51.25 ± 0.49^{fg}	48.13 ± 0.2^{i}	61.78 ± 1.51^{c}	51.27 ± 0.21^{fg}	48.47 ± 0.56^{i}
γ-Terpinene	0.83 ± 0.02^{l}	1.32 ± 0.06^{ij}	1.55 ± 0.07^{e}	0.96 ± 0.03^{k}	1.43 ± 0.01^{fghi}	1.75 ± 0.04^{cd}
δ-Terpineol	1.78 ± 0.05^{g}	2.03 ± 0.02^{cde}	2.13 ± 0.05^{bc}	2.12 ± 0.07^{bc}	1.83 ± 0.01^{fg}	1.74 ± 0.05^{g}
Terpinen-4-ol	3.67 ± 0.08^{fg}	3.46 ± 0.03^{h}	4.02 ± 0.03^{bcd}	4.04 ± 0.02^{bc}	3.23 ± 0.02^{i}	3.87 ± 0.04^{cde}
α-Terpineol	10 ± 0.04^{g}	9.46 ± 0.08^{cde}	9.75 ± 0.07^{bc}	10.5 ± 0.44^{bc}	8.75 ± 0.06^{fg}	8.31 ± 0.03^{g}
Germacrene D	0 ± 0	0.96 ± 0.01^{fg}	1.28 ± 0.02^{dc}	0 ± 0	0.6 ± 0.01^{l}	1.24 ± 0.06^{ed}
β-Selinene	0.68 ± 0.02^{jk}	0.77 ± 0.01^{hij}	1.2 ± 0.05^{e}	0.79 ± 0.08^{hi}	1.81 ± 0.03^{c}	0.99 ± 0.06^{f}
trans-Nerolidol	3.44 ± 0.11^{i}	3.89 ± 0.04^{fg}	5.12 ± 0.05^{c}	3.82 ± 0.01^{fgh}	3.66 ± 0.01^{ghi}	4.37 ± 0.08^{de}
Longifolenaldehyde	1.14 ± 0.05^{dc}	1.54 ± 0.02^{b}	1.48 ± 0.04^{b}	1.26 ± 0.02^{c}	0.69 ± 0.01^{hi}	0.94 ± 0.04^{ef}
(E)-15,16-	0 ± 0	0.54 ± 0.02^{g}	0.8 ± 0.03^{d}	0 ± 0	0 ± 0	0.85 ± 0.05^{cd}

Note: Values presented are means ± SD of triplicate values. Values with different letters in the superscripts differ significantly ($p<0.05$).

Table 26: The volatile composition of samples processed using traditional local bhatti and smokeless bhatti drying methods

Compounds	Local bhatti 2	Local bhatti 3	Smokeless	Smokeless	Smokeless	Smokeless
β-Thujene	1.06±0^{e}	1.29±0.02^{a}	0.81±0.05^{i}	1.16±0.01^{c}	1.29±0.02^{a}	1.05±0^{e}
α-Pinene	7.19±0.14^{fg}	7.77±0.17^{ab}	7.37±0.12^{def}	6.77±0.17^{h}	7.72±0.14^{abc}	7.23±0.13^{efg}
4(10)-Thujene/	4.42±0.01^{ef}	4.36±0.12^{f}	4.33±0.16^{f}	3.74±0.06^{g}	5.26±0.08^{a}	4.28±0.03^{f}
.(-)-β-Pinene	7.96±0.22^{bcde}	8.25±0.12^{abc}	7.96±0.15^{bcde}	7.92±0.22^{cde}	8.2±0.12^{abc}	8.43±0.23^{a}
β-Myrcene	2.89±0.04^{ef}	3.17±0.05^{c}	2.46±0.13^{j}	2.49±0.05^{j}	3.38±0.03^{a}	2.79±0.03^{fg}
α-Terpinene	1.21±0.02^{a}	1.14±0.01^{ab}	0.79±0.07^{d}	1.13±0^{ab}	1.23±0.03^{a}	1.18±0.02^{ab}
1,8-Cineole	49.28±0.59^{ghi}	49.07±0.76^{hi}	58.71±2.34^{d}	48.87±0.53^{hi}	47.93±0.53^{i}	49.89±0.11^{fghi}
γ-Terpinene	1.85±0.03^{ab}	1.92±0.01^{a}	1.28±0.12^{j}	1.8±0.02^{bc}	1.87±0.03^{ab}	1.73±0.02^{cd}
δ-Terpineol	1.99±0.03^{de}	1.78±0.04^{g}	1.43±0.15^{i}	2.18±0.03^{b}	1.78±0.03^{g}	1.97±0.03^{e}
Terpinen-4-ol	3.99±0.03^{bcd}	3.97±0.05^{cd}	3.12±0.29^{i}	4.17±0.01^{ab}	3.53±0.03^{gh}	4.05±0.03^{bc}
α-Terpineol	9.21±0.05^{de}	8.64±0.13^{g}	7.91±0.52^{i}	9.82±0.02^{b}	8.56±0.09^{g}	9.08±0.03^{e}
Germacrene D	0.92±0.01^{hg}	1.2±0.04^{e}	0.68±0.03^{k}	1.31±0.04^{c}	1.51±0.05^{b}	0.92±0.02^{gh}
β-Selinene	0.91±0.03^{fg}	0.96±0.03^{fg}	0.64±0.03^{k}	1.9±0.05^{b}	0.93±0.03^{fg}	0.82±0.02^{hi}
trans-Nerolidol	4.22±0.02^{e}	4.4±0.09^{de}	2.87±0.33^{j}	5.8±0.02^{b}	4.42±0.06^{de}	4.33±0.01^{de}
Longifolenaldehyde	0.92±0.02^{efg}	0.61±0.02^{i}	0.82±0.12^{hfg}	0±0	0.72±0.03^{hi}	0.79±0.02^{gh}
(E)-15,16-	0.94±0.03^{b}	0.89±0.03^{bc}	0.57±0.01^{gf}	0±0	0.62±0.01^{f}	0.57±0.08^{fg}

Note: Values presented are means ± SD of triplicate values. Values with different letters in the superscripts differ significantly ($p<0.05$).

Table 27: The volatile composition of farmer-processed samples obtained through solar drying, cabinet drying, oven drying and local bhatti methods.

Compounds	Solar dried Farmer (%)	Cabinet Dried Farmer (%)	Oven Dried Farmer (%)	Local bhatti Farmer 1 (%)	Local bhatti Farmer 2 (%)	Local bhatti Farmer 3 (%)
β-Thujene	1.11 ± 0.01^{cd}	1.13 ± 0.01^{cd}	1.21 ± 0.01^{b}	1.08 ± 0.03^{de}	1.14 ± 0.04^{c}	0.98 ± 0.01^{f}
α-Pinene	7.5 ± 0.13^{bcde}	7.7 ± 0.13^{abc}	7.59 ± 0.1^{abcd}	7.41 ± 0.12^{def}	7.48 ± 0.12^{cde}	7.18 ± 0.08^{fg}
4(10)-Thujene/	4.76 ± 0.02^{cd}	5.26 ± 0.08^{a}	4.79 ± 0.05^{cd}	5.3 ± 0.18^{a}	4.6 ± 0.1^{de}	4.29 ± 0.02^{f}
.(-)-β-Pinene	8.03 ± 0.2^{bcd}	8.03 ± 0.12^{bcd}	8.02 ± 0.08^{bcd}	8.34 ± 0.1^{ab}	8.58 ± 0.17^{a}	8.35 ± 0.11^{ab}
β-Myrcene	3.07 ± 0.05^{d}	3.04 ± 0.04^{d}	3.12 ± 0.03^{cd}	2.88 ± 0.07^{ef}	2.94 ± 0.03^{e}	2.69 ± 0.03^{gh}
α-Terpinene	1.16 ± 0.01^{ab}	1.07 ± 0.02^{b}	1.24 ± 0.02^{a}	0.88 ± 0.04^{cd}	1.14 ± 0.03^{ab}	0.97 ± 0.01^{c}
1,8-Cineole	50.58 ± 0.44^{fgh}	51.38 ± 0.43^{fg}	49.75 ± 0.02^{fghi}	51.58 ± 0.51^{f}	48.33 ± 0.4^{i}	54.41 ± 0.21^{e}
γ-Terpinene	1.7 ± 0.02^{cd}	1.52 ± 0.02^{ef}	1.86 ± 0.03^{ab}	1.34 ± 0.05^{hij}	1.67 ± 0.01^{d}	1.44 ± 0^{fgh}
δ-Terpineol	1.91 ± 0.01^{ef}	1.85 ± 0.01^{fg}	1.92 ± 0.02^{ef}	1.84 ± 0.03^{fg}	1.83 ± 0.02^{fg}	1.55 ± 0.02^{h}
Terpinen-4-ol	3.92 ± 0.01^{cd}	3.65 ± 0.01^{gf}	3.83 ± 0.01^{def}	3.23 ± 0.04^{i}	3.73 ± 0.05^{ef}	3.28 ± 0.01^{i}
α-Terpineol	9.01 ± 0.04^{ef}	8.66 ± 0.05^{fg}	9.12 ± 0.01^{ef}	8.8 ± 0.06^{fg}	8.3 ± 0.12^{fg}	7.57 ± 0.02^{h}
Germacrene D	0.96 ± 0.02^{gf}	0.79 ± 0.01^{j}	0.96 ± 0.03^{gf}	0.6 ± 0.01^{l}	1.25 ± 0.03^{ed}	1.02 ± 0.03^{f}
β-Selinene	0.75 ± 0.02^{ij}	0.72 ± 0.02^{ijk}	0.82 ± 0.04^{hi}	1.83 ± 0.05^{bc}	2.36 ± 0.02^{a}	0.96 ± 0.03^{fg}
trans-Nerolidol	3.66 ± 0.03^{ghi}	3.44 ± 0.04^{i}	3.92 ± 0.04^{f}	3.67 ± 0.03^{igh}	4.55 ± 0.07^{d}	4 ± 0.03^{f}
Longifolenaldehyde	1.05 ± 0.02^{de}	1.05 ± 0.01^{de}	0.62 ± 0.03^{i}	0.68 ± 0.01^{hi}	0.87 ± 0.02^{fg}	0.74 ± 0.02^{hi}
(E)-15,16-Dinorlabda-	0.68 ± 0.01^{e}	0.69 ± 0.03^{e}	0.7 ± 0.01^{e}	0±0	0±0	0±0

Note: HD – Hybrid Dried FD- Freeze Dried CD- Cabinet Dried. Values with different letters in the superscripts differ significantly ($p<0.05$). Values presented are means ± SD of triplicate values

The statistical analysis showed that the volatile composition of large cardamom varied significantly ($p < 0.05$) with different drying methods. Among the identified compounds, 1,8-Cineole was the most abundant, ranging from 47.93% to 73.57%, with the highest value observed in freeze-dried samples. Other major volatiles included α-Terpineol (5.69%–13.42%) and (–)-β-Pinene (5.05%–8.58%), which were consistently present across samples. In contrast, compounds such as (E)-15,16-Dinorlabda-8(17),11-dien-13-one (0–1.46%), Germacrene D (0–1.58%), and β-Selinene (0.64%–2.36%) were detected in much lower proportions. When comparing laboratory-scale and farmer-level drying, freeze-dried samples consistently retained higher proportions of oxygenated monoterpenes, whereas cabinet and hybrid drying resulted in reduced levels. Farmer-processed local bhatti samples maintained relatively higher diversity and concentration of volatiles compared to smokeless bhatti samples, which exhibited a narrower volatile profile. According to (Vijayan et al., 2017), analysis of the essential oil revealed that its predominant components were 1,8-cineole (63.2–73.4%), β-pinene (4.0–11.1%), α-terpineol (5.6–7.6%), and α-pinene (1.7–6.5%). The observed variations can be attributed to the effect of drying conditions on thermolabile compounds, smoke exposure, oxidative reactions and compositional differences among varieties (Vijayan et al., 2017).

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3.3. Development and verification of value addition technology in mushroom for Bagmati Province

3.3.1. Development of ready-to-eat dehydrated soup mixes from mushroom

This study focused on developing ready-to-eat dehydrated soup mixes using oyster mushroom powder, corn starch, and skim milk powder through Minitab mixture design. Proximate and mineral analyses (AOAC, 2023) and statistical evaluation (ANOVA, SNK test) showed wide variations: moisture 6.08–8.53%, protein 0.97–27.12%, fat 0.078–1.74%, calcium 43.32–1161.17 mg/100g, phosphorus 22–911.45 mg/100g, and iron 0.28–6.44 mg/100g. Formulation 6 excelled in protein, iron, and phosphorus; formulation 10 in calcium and phosphorus. Results shows that mushroom–milk soups as nutritious, shelf-stable, functional foods.

Ready-to-eat dehydrated soup mixes have become a popular choice for convenient and quick meals, especially in today's fast-paced lifestyle. These mixes are typically made by blending ingredients like corn starch, spices, salt, flavorings, and taste enhancers. When prepared, they are rehydrated with hot water or stock, allowing the flavors to blend and form a nourishing broth. Soups are not only enjoyed as comforting meals but also serve an important role in dietary care, particularly for people recovering from illness who may have difficulty consuming solid food (Sinchaipanit et al., 2023). They are gentle on the stomach and provide essential nutrients in an easily digestible form. Beyond their therapeutic use, soups are often served as appetizers because they help stimulate the appetite and encourage the production of digestive juices, preparing the body for a full meal (Kumari et al., 2023). One of the key advantages of dried soup powders is their long shelf life. The low moisture content protects them from spoilage caused by enzymes and oxidation, helping to preserve flavor and quality at room temperature for extended periods (Sinchaipanit et al., 2023).

Mushrooms are widely regarded as a safe, nutritious, and versatile food suitable for people of all ages. Often described as a "complete food," they can effectively replace or complement meat, fish, fruits, and vegetables in the diet. Fresh mushrooms are made up of about 85–95% water, with the remaining portion containing approximately 3.0% protein, 4.0% carbohydrates, 0.3–0.4% fat, and 1.0% minerals and vitamins (Hamza et al., 2024). What makes mushrooms especially valuable is their well-balanced nutritional profile, offering high-quality protein, essential amino acids, vitamins, minerals, and bioactive compounds. This makes them ideal for use in food supplementation and functional food development. They pair well with cereal-based diets, helping to improve the overall protein quality of the meal. Because of their rich umami flavor and health benefits, mushrooms are increasingly being used in a wide range of food products, including soups, sausages, bakery items, health drinks, and ready-to-eat meals (Sinchaipanit et al., 2023; Kumari et al., 2023).

Here 10 different formulations for the soup powder with corn starch powder and skim milk powder as other ingredients in addition to oyster mushroom powder, were made using Minitab mixture design and proximate and minerals analysis were performed for all 10 formulations according to (AOAC,2023) (Table 28).

Table 28: Proximate and mineral analysis of different formulations.

Formulation	Moisture%	Fat%	Protein %	Iron (mg/100g)	Phosphorus (mg/100g)	Calcium (mg/100g)
1	6.612±0.24	0.66±0.02e	18.61±0.2	3.412±0.5	492.24±11.9	222.311±1.8
2	8.159±0.75	0.078±0.0	0.97±0.21	0.282±0.1	22.00±19.73i	43.324±1.93
3	6.828±0.40	0.846±0.0	15.14±0.2	6.018±0.5	118.42±6.32	37.097±2.53
4	6.37±0.29c	1.361±0.0	26.91±0.2	4.277±0.3	349.96±2.96	51.508±1.02f
5	6.08±0.38c	1.135±0.0	22.13±0.1	3.131±0.1	376.71±3.17	217.751±6.2
6	6.1±0.091c	1.743±0.0	27.12±0.2	6.444±0.1	696.72±25.6	471.726±1.2
7	8.535±0.02	0.655±0.0	10.76±0.1	2.527±0.3	260.47±4.51	193.516±1.7

Note: $^{a-i}$ Values with different letters in the superscripts differ significantly(P<0.05). Values presented are means ± SD of triplicate values.

Moisture Content

Moisture content ranged from 6.08% to 8.535%, with formulation 7 having the highest moisture (8.535%) and formulation 5 the lowest (6.08%). These values are within the typical range for dried food powders, which generally have moisture levels below 10% to ensure microbial stability and prevent caking during storage. A lower moisture content is associated with a longer shelf life, as it reduces the water activity of the product, making it less susceptible to spoilage by microorganisms and less prone to clumping. Formulations with moisture levels closer to 6% (e.g., 1, 3, 4, 5, 6) are likely to be more stable, which is a critical factor for a product intended for long-term storage in the Nepali market.

Protein Content

Protein content showed the most dramatic variation, ranging from 0.97% in formulation 2 to 27.12% in formulation 6. This wide range is a direct consequence of the ingredient ratios. Formulation 2, composed entirely of corn starch, is naturally low in protein. In contrast, formulations 4, 6, and 10, which have high proportions of oyster mushroom powder and skim milk powder, exhibit significantly higher protein levels. Oyster mushrooms are a well-known source of high-quality protein, containing all essential amino acids, while skim milk powder is rich in casein and whey proteins. The protein content in formulations like 6 and 10 exceeds that of many commercial instant soups, positioning them as valuable sources of dietary protein. This is particularly important in regions where protein-energy malnutrition is a concern, as such a product can contribute significantly to meeting daily protein requirements.

Fat Content

Fat content was generally low across all formulations, ranging from 0.078% to 1.743%. The highest fat content was found in formulation 6, which can be attributed to the natural lipids present in oyster mushroom powder. Corn starch and skim milk powder are both very low in fat, which explains the minimal fat levels in formulations dominated by these ingredients. This low-fat profile makes the soup powder a heart-healthy option, suitable for individuals managing their cholesterol levels or seeking low-calorie meals. The fat present in the mushroom also contributes to the absorption of fat-soluble vitamins and enhances the overall flavor and mouthfeel of the reconstituted soup.

Calcium and Phosphorus Content

The data for calcium and phosphorus reveals a clear synergy between these two minerals. Calcium content ranged from 43.32 mg/100g in formulation 2 to a remarkable 1161.17 mg/100g in formulation 10. Similarly, phosphorus content ranged from 22 mg/100g to 911.45 mg/100g. This strong correlation is expected, as both minerals are abundant in dairy products. Skim milk powder is a primary source of calcium, while both skim milk and oyster mushrooms contribute to the phosphorus content. The high levels in formulations 8, 9, and 10 highlight their potential as functional foods for bone health. The calcium-to-phosphorus ratio in these formulations is likely favorable, which is essential for optimal bone mineralization. This makes them particularly beneficial for children, adolescents, and the elderly, who have higher requirements for these nutrients.

Iron Content

Iron content varied from 0.282 mg/100g in formulation 2 to 6.444 mg/100g in formulation 6. The high iron levels in formulations 3, 4, 6, and 10 are a direct result of the inclusion of oyster mushroom powder, which is known to be a good non-heme iron source. Iron is a critical nutrient for preventing anemia, a widespread health issue, particularly among women and children. Formulation 6, with its high iron and protein content, could be an effective dietary intervention for improving iron status, especially when consumed with a source of vitamin C to enhance non-heme iron absorption.

Overall Nutritional Implications

The data clearly identifies formulations 6 and 10 as the most nutritionally robust. Formulation 6 (50% mushroom,and 50% milk) excels in protein, iron, and phosphorus, making it an excellent choice for overall nutrition. Formulation 10 (0% mushroom, 0% starch, 100% milk) is a powerhouse for calcium and phosphorus, ideal for bone health. Formulation 8 also stands out for its high mineral content. In contrast, formulation 2, being pure starch, offers minimal nutritional value beyond carbohydrates, confirming the importance of incorporating nutrient-dense ingredients like mushrooms and milk solids.

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3.3.2. Development of biodegradable plastic from cassava (s*imal tarul*)

This study focused on developing biodegradable plastic films from *Simal Tarul* (Cassava) starch and evaluating their physical, barrier and water-interaction properties. Biodegradable plastics derived from natural polymers such as starch are gaining attention due to their eco-friendliness, availability, and ability to replace petroleum-based plastics. Cassava, an underutilized crop in Nepal, was selected as the starch source due to its high starch yield, low cost, and effective film-forming potential.

Using Response Surface Methodology (RSM) with a Central Composite Design (CCD), cassava starch and glycerol (plasticizer) concentrations were optimized across 13 experimental runs. Films were prepared using the casting method, followed by controlled drying. Their properties were assessed in terms of thickness, solubility, water vapor transmission rate (WVTR), and water absorption. Thickness ranged between 0.15–0.67 mm, solubility varied from 9.56% -25.30%, WVTR from 18.01 - 41.99 g m^{-2} day^{-1} and Water absorption ranged from 85.83% - 208.86%. Results obtained showed range due to variation in starch and glycerol content in between formulations.

Biodegradable plastics are degradable plastics in which naturally occurring microorganisms such as bacteria, fungi and algae can result in their degradation by reducing long term waste. Films made from renewable and natural polymers which can degrade naturally over time and rapidly in comparison to petroleum-based plastics are gaining interest (Ezeoha, 2013). Some natural polymers are starch, cellulose, chitin, chitosan, gelatin, soy protein, whey protein and several other polysaccharides and proteins (Bajpai, 2020).

Starch is one of the biopolymers which has the most potential for biodegradable film(Ezeoha, 2013). Since it is one of the most abundant biopolymers on earth, various studies have been done for the development of starch-based films. Besides being widely available, starch is a low-cost material, edible, tasteless, colorless and easy to use in technological processes (Cortés-Rodríguez et al., 2020). Various starch sources are present, some are corn, potato, sweet potato, yam, rice and cassava(Daiuto et al., 2005).

The biopolymers prepared from cassava starch have shown excellent properties in film formation, showing their potential for their development (Cortés-Rodríguez et al., 2020). *Simal Tarul*, commonly known as Cassava (*Manihot esculenta Crantz*), is a perennial crop cultivated in tropical and subtropical regions of the world. Out of the approximately 100 species of *Manihot* genus, Cassava is the only commercially cultivated crop for its edible, starchy, tuberous root (Liu et al., 2014). *Simal Tarul* is considered an underutilized crop species and is consumed as traditional supplementary food for humans or animal feed in processed form in Nepal (Gurung et al., 2020). Cassava can be used as a raw material for various industrial purposes like sugar production due to its high starch content (Fathoni et al., 2020).

Research Design for development of biodegradable plastic

Minitab Statistical Software Version 22 was used to develop experimental design for development of biodegradable plastic, which used Response Surface Methodology (RSM). Two independent variables, weight of prepared cassava starch and percentage of glycerol were subjected to a Central Composite Design (CCD). A total of 13 experimental runs were obtained with two-level full factorial points, four axial points, four cube points and five center points in cube.

Table 29: Central composite design for preparation of biofilm

Run Order	Starch		Glycerol	
	Coded	**Actual value (%)**	**Coded**	**Actual value (%)**
1	0	5.5	0	32.5
2	0	5.5	0	32.5
3	0	5.5	0	32.5
4	0	5.5	-1.41421	7.7513
5	1	8	1	50
6	1	8	-1	15
7	-1.41421	1.96447	0	32.5
8	0	5.5	1.41421	57.2487
9	-1	3	1	50
10	-1	3	-1	15
11	0	5.5	0	32.5
12	0	5.5	0	32.5
13	1.41421	9.03553	0	32.5

Preparation of Starch Films

The starch films were prepared according to(Müller et al., 2008) with minor modifications. The films were prepared by casting technique using film forming solution containing cassava starch concentrations according to central composite design. Glycerol was added at various concentrations (32.5%, 7.7513%, 50%, 15%, 32.5%, 57.2487%, 5% / g dry starch) as plasticizer. The mixture was heated to boiling on a hot plate and stirred continuously until the solution turned clear and thick. The mixture was cooled until bubbles vanished and the mixture was poured in oiled petri plates. The plates were then dried at 45 °C for about 6 hours. The dried films were peeled and stored in airtight polyethylene bags.

Table 30: Physical, barrier and water interaction analysis of prepared biodegradable plastic

Formulation	Composition	Thickness (mm)	Solubility (%)	WVTR (g m^{-2}	Water absorption
1,2,3,11,12	S:5.5g,	0.29±0.015^{de}	19.74±0.90^{d}	41.99±0.79^{a}	110.35±1.06^{f}
4	S:5.5g,	0.29±0.03^{de}	9.56±0.23^{h}	18.01±0.18^{g}	208.86±0.32^{a}
5	S:8g, G:50%	0.78±0.02^{a}	24.71±0.64^{a}	31.49±0.44^{b}	131.77±1.08^{d}
6	S:8g, G:15%	0.67±0.03^{b}	14.31±0.73^{g}	25.11±0.74^{d}	132.48±1.07^{d}
7	S:1.96g,	0.15±0.02^{f}	17.36±0.29^{e}	20.40±0.55^{f}	85.83±0.9^{h}
8	S:5.5g,	0.38±0.02^{c}	22.31±0.57^{b}	28.64±0.56^{c}	111.84±0.43^{e}
9	S:3 g, G:50%	0.24±0.05^{e}	21.05±0.74^{c}	23.38±0.73^{e}	98.94±0.37^{g}
10	S:3 g, G:15%	0.32±0.01^{d}	16.20±0.44^{f}	18.66±0.72^{g}	144.33±0.79^{c}
13	S:9.03g,	0.65±0.03^{b}	25.30±0.37^{a}	23.59±0.87^{e}	165.69±1.07^{b}

Note: The letter in superscript indicates a significant difference at $p<0.05$. Values expressed are mean ± standard deviation.

- **Film thickness**

Film thickness varied from 0.15mm to 0.67mm across formulations with formulation 6 having the highest thickness of 0.67±0.03 mm followed by formulation 13 with thickness 0.65±0.03mm. Formulation 7 had the lowest thickness with 0.15±0.02mm. Formulation 6 and 13 had the highest percentage of starch and glycerol and formulation 7 had the lowest starch content. Higher plasticizer content can increase the film thickness due to the property of glycerol in disrupting and restructuring of interpolymer chain networks, creating more spaces(Ibrahim et al., 2019; Sanyang et al., 2016).

- **Solubility in Water**

Formulation 13 had the highest solubility in water (25.30±0.37 %), followed closely by formulation 5 (24.71±0.64) whereas formulation 4 had the lowest solubility in water (9.56±0.23 %). Formulations 13 and 5 had both higher starch content and glycerol content. Plasticizer content reduce the interaction between polymer molecules which creates larger free space in structure of polymer chain. This allows the penetration of water fragments in the film matrix which increase film solubility (Ibrahim et al., 2019; Sirbu et al., 2024). Increase of O-H bonds on cassava starch films with the increase of glycerol concentration that is more available to interact with water molecules attracted by hygroscopic property of glycerol cause more solubility in water (Theamdee & Pansaeng, 2019).

- **Water vapour transmission rate (WVTR)**

WVTR varied among the formulations with formulation 1 having the highest WVTR (41.99±0.79 g m^{-2} day^{-1}) and formulation 4 having the lowest (18.01±0.18 g m^{-2} day^{-1}). Formulation 4 had one of the lowest glycerol contents among all the formulations. Higher glycerol content increases WVTR due to its hydrophilic property. This can reduce intermolecular forces and increase mobility of polymer chains, facilitating migration of water vapor molecules through the film (Jouki et al., 2013). Along with glycerol, the water added also act as plasticizer enhancing segmental mobility and water sorption increasing permeability (Yang et al., 2024).

- **Water absorption**

Water absorption ranged from 85.83 ± 0.9% (formulation 7, low starch) and 208.86 ± 0.32% (formulation 4, low glycerol). Films with low glycerol levels (7.75%/g dry starch) exhibited the highest water absorption, while moderate to high glycerol concentrations (15–32.5%/g dry starch) reduced the water uptake.

The high-water absorption may be due to rigid and porous structure of the starch network in absence of sufficient plasticizer, facilitating swelling and absorption. On the other hand, glycerol at moderate concentrations improved homogeneity of polymer matrix, reducing porosity and ultimately water absorption. Glycerol formed a stronger hydrogen bond with starch preventing water molecules from combining with plasticizer or starch (Tarique et al., 2021).

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3.3.2. Development of mushroom kimchi

This study developed and verified mushroom kimchi technology in Bagmati Province using oyster mushrooms as a functional food base. Kimchi's lactic acid fermentation lowered pH, preserved nutrients, and enhanced bioavailability. Oyster mushrooms added protein, fiber, minerals, and phenolics, addressing malnutrition and sustainability. Fermentation trials (5–7 days) showed stable moisture, low fat, rising protein, moderate iron, declining phosphorus, and best sensory acceptance at ~5.76 days. Thus, optimized mushroom kimchi offers a nutritious, shelf-stable, eco-friendly, and consumer-acceptable value-added product.

Kimchi is a traditional Korean fermented vegetable product that has established itself as a globally useful functional food. The most widely consumed form of kimchi, known as baechu (Chinese cabbage; Brassica rapa subsp. pekinensis), is seasoned with chili pepper, garlic, ginger and fermented fish sauce before lactic acid fermentation (Jayaseelan et al., 2024). The key bacterial general responsible for kimchi fermentation include *Leuconostoc*, *Lactobacillus* and *Weissella* (Park et al., 2015). As kimchi ferments, the pH decreases, titratable acidity increases and volatile compounds accumulate, resulting in the characteristic sour, umami-rich taste and slightly effervescent texture (Akola et al., 2023). It is traditionally consumed as a side dish, but due to its probiotic and antioxidant properties, it is being incorporated into modern dishes as a functional ingredient. Kimchi is a versatile food matrix that can incorporate various substrates for fermentation, such as mushrooms, which are rich in nutrients and bioactive compounds. Oyster mushrooms are rich in protein, dietary fiber and essential minerals (Sultana et al., 2024). Additionally, the acidic conditions of kimchi storage might assist in preserving thermolabile nutrients and improving their digestibility and bioavailability. Mushroom-based kimchi seamlessly marries the traditional science of fermentation with modern nutritional innovation. Therefore, developing and optimizing oyster mushroom kimchi as a functional food is essential.

Because of the high moisture content (above 80%), fresh oyster mushrooms are extremely perishable and have a postharvest shelf-life of merely 2–4 days in ambient conditions (Sultana et al., 2024). Due to these characteristics, mushrooms have a short shelf life, which poses significant economic challenges and limits their market availability. Therefore, there is a need for value addition through product development to boost the marketability and shelf life of the products (Akola et al., 2023). Cooperation of natural properties and lactic acid bacteria that are responsible for fermentation during which they turn sugars into lactic acid. The lactic acid bacteria in kimchi can boost the bioavailability of minerals like iron and phosphorus in oyster mushrooms. Mushrooms are also plentiful in β-glucans, phenolic compounds and essential amino acids, which support their hypoglycemic, immunomodulatory and hypo-cholesterolemic effects. Moreover, turning mushrooms into fermented products is consistent with the overall direction of the global food industry toward plant-based, functional foods that promote gut health. In the developing countries where protein-energy malnutrition and micronutrient deficiency are prevalent, the mushroom-based fermented products could be a cheap source of vital nutrients (Charles et al., 2024). Additionally, growing oyster mushrooms on the agricultural waste-based substrate promotes environmental sustainability and recycling (Akola et al., 2023). Hence, utilizing oyster mushrooms for the production of kimchi transcends the food preservation strategy and establishes a solid foundation for implementing the innovative approach to economic development. This seeks to address food security, nutrition and circular economy in the food system.

Mushroom kimchi represents a new variation of traditional kimchi where the usual cabbage base is replaced or supplemented by edible fungi, in this case oyster mushrooms (Pleurotus ostreatus), to create a healthier, vegetarian fermented food. Unlike cruciferous vegetables, oyster mushrooms yield a unique biochemical profile with good protein composition (29.4% on dry basis), dietary fiber, and essential minerals such as potassium, phosphorus, and iron, alongside bioactive phenolics and β-glucans (Sultana et al., 2024; Charles et al., 2024). Such characteristics make mushroom kimchi a likely functional food that has the ability to control malnutrition and improve gut health. The process of fermentation by indigenous lactic acid bacteria not only imparts the characteristic tanginess to flavor and aroma but also enhances digestibility and nutritional bioavailability (Jayaseelan et al., 2024). Data in recent years have proven that processed mushroom products like flours, powders, and fermented ones can significantly boost nutrient value in staple foods, and therefore mushroom kimchi can be an equal contributor to dietary diversification (Charles et al., 2024). The inclusion of mushrooms in kimchi contributes textural depth, with a meaty, umami-tasting mouthfeel that is appealing to vegetarian and flexitarian shoppers. Thermo-processing procedures such as blanching and shrink dehydration, used in this study, minimize moisture content, inactivate enzymatic spoilage, and allow for a more favorable substrate for controlled fermentation (Akola et al., 2023). Sensory attributes such as smell, feel, and taste play a major role in consumer acceptability, and optimization using statistical tools like response surface methodology can decide on optimal fermentation time. This study evaluates the 5, 6, and 7-day fermented oyster mushroom kimchi based on proximate composition, minerals (phosphorus and iron), and sensory performance to determine the optimal fermentation time, hence contributing to new functional fermented foods.

Fresh oyster mushrooms were sorted, sliced, washed, and blanched at 85°C for 3 minutes. They were then rinsed, treated with 0.3% KMS for 15 minutes, drained, and dried to 40% moisture at 66.43°C. For kimchi preparation, a cooked rice flour base was blended with garlic, ginger, onion, salt, Kashmiri chili powder, and garlic leaves, then mixed with the dried mushrooms. The mixture was packed in glass jars with headspace and fermented at room temperature for 5, 6, or 7 Days.

The present study evaluated the physicochemical, nutritional, and sensory characteristics of oyster mushroom kimchi fermented for 5, 6, and 7 days at room temperature. The results indicate a clear trend in changes associated with fermentation time, which significantly influences pH, moisture content, proximate composition, mineral profile, and consumer acceptability. These findings are critical for determining the optimal fermentation period to achieve maximum nutritional quality and sensory appeal.

Table 31: Chemical properties of kimchi fermented for different time

Sample	pH	Moisture%	Fat%	Protein%	Iron (mg/100g)	Phosphorus (mg/100g)	Sensory overall acceptance
Kimchi day 5	3.41±0a	69.19±0.59a	0.039±0a	4.28±0.03a	0.3±0a	71.71±0.235a	7.625±0.8
Kimchi day 6	3.38±0.01b	70.86±1.27a	0.037±0b	4.25±0.034a	0.41±0.2a	57.2±0.322b	7±1.22
Kimchi day 7	3.32±0.01c	70.52±0.39a	0.037±0b	4.51±0.086b	0.37±0.05a	50.55±0.296c	7.25±1.64

[a-i] Values with different letters in the superscripts differ significantly($P<0.05$). Values presented are means ± SD of triplicate values

pH Analysis

The pH values decreased progressively from day 5 (3.41 ± 0.00) to day 7 (3.32 ± 0.01), indicating an increase in acidity over time. This decline is characteristic of lactic acid fermentation, where lactic acid bacteria (LAB) metabolize sugars into lactic acid, thereby lowering the pH (Jayaseelan et al., 2024). A lower pH not only enhances flavor but also acts as a natural preservative by inhibiting the growth of spoilage and pathogenic microorganisms (Charles et al., 2024). The observed pH range (3.32–3.41) falls within the typical acidic range of traditional kimchi (3.0–4.0), confirming successful fermentation (Akola et al., 2023). The significant difference ($p < 0.05$) between day 5 and day 7 suggests that fermentation continues to progress beyond day 5, with continued acid production.

Moisture Content

Moisture content remained relatively stable across all fermentation periods, ranging from 69.19% to 70.86%, with no significant differences ($p > 0.05$). This stability indicates that the water activity (aw) of the kimchi was maintained within a safe range, which is crucial for ensuring microbial safety and extending shelf life (Sultana et al., 2024). The high moisture content is consistent with the nature of fermented vegetable products, especially those involving blanched and rehydrated ingredients like mushrooms. However, the slight increase from day 5 to day 6 may be attributed to the release of cellular fluids during ongoing enzymatic activity or minor water absorption due to osmotic pressure changes (Nambafu et al., 2022).

Fat Content

Fat content showed minimal variation among the samples, with values ranging from 0.037% to 0.039%. The absence of significant differences ($p > 0.05$) suggests that fat degradation or synthesis did not occur substantially during fermentation. This is expected, as oyster mushrooms naturally contain low levels of fat (typically 0.5–2.6%), and fermentation primarily affects carbohydrates and proteins rather than lipids (Reis et al., 2012; Nagulwar & More, 2020). The negligible fat content aligns with the health-promoting profile of mushroom-based foods, particularly for individuals managing cardiovascular conditions (Nagulwar & More, 2020).

Protein Content

Protein content increased significantly from day 5 ($4.28 \pm 0.03\%$) to day 7 ($4.51 \pm 0.086\%$), with a notable rise between day 6 and day 7. This increase may be attributed to proteolytic enzyme activity by LAB and other microbes, which break down complex proteins into peptides and free amino acids, potentially enhancing bioavailability (Charles et al., 2024). Additionally, the partial drying of mushrooms prior to kimchi preparation may have concentrated protein content, while fermentation could further enrich it through microbial biomass accumulation (Sultana et al., 2024). The observed protein levels are comparable to those reported in other mushroom-based fermented products, such as oyster mushroom patties (Biswas & Bodhankar, 2023).

Iron Content

Iron content was highest on day 6 (0.41 ± 0.2 mg/100g) and slightly lower on days 5 and 7 (0.30 ± 0.00 and 0.37 ± 0.05 mg/100g, respectively). Although the differences were not statistically significant ($p > 0.05$), the trend suggests that fermentation may enhance iron solubility or bioaccessibility through the action of organic acids and microbial metabolites (Reis et al., 2012). Iron is a vital micronutrient, and its retention in fermented foods is beneficial for preventing iron-deficiency anemia, especially in populations reliant on plant-based diets (Charles et al., 2024). The moderate iron levels observed here support the use of oyster mushroom kimchi as a functional food.

Phosphorus Content

Phosphorus content declined significantly from day 5 (71.71 ± 0.235 mg/100g) to day 7 (50.55 ± 0.296 mg/100g), with a sharp drop between day 6 and day 7. This reduction may be due to microbial uptake of phosphorus during fermentation or the formation of insoluble complexes with calcium or other minerals (Nambafu et al., 2022). Phosphorus is essential for bone health and energy metabolism, and its preservation is important for nutritional value. However, excessive loss could compromise the mineral balance of the product. Therefore, day 5 appears to be optimal for retaining phosphorus.

Sensory Overall Acceptance

Sensory evaluation revealed that kimchi fermented for 5 days received the highest overall acceptance score (7.625 ± 0.86), followed by day 7 (7.25 ± 1.64) and day 6 (7.0 ± 1.22). While the differences were not statistically significant ($p > 0.05$), the trend indicates that consumers preferred the flavor, aroma, and texture of the 5-day sample. This preference may be linked to a more balanced acidity and less intense fermentation odor, which can become overpowering after prolonged fermentation (Akola et al., 2023). The high sensory scores suggest that the kimchi is palatable and suitable for consumption, supporting its potential as a commercial product.

Optimization and Conclusion

Based on response optimization using Minitab, the best formulation was identified as the 5.76-day fermented kimchi, which exhibited optimal pH, high phosphorus retention, good protein content, and superior sensory acceptance. This conclusion is supported by the fact that day 5.76 provided the most favorable combination of nutritional and sensory attributes. Prolonged fermentation beyond this point led to declining phosphorus levels and marginally reduced sensory appeal, despite increased protein content.

In summary, the results demonstrate that fermentation duration significantly impacts the quality of oyster mushroom kimchi. Day 5.76 emerges as the ideal fermentation period, balancing nutritional integrity, microbial safety, and consumer preference. This finding contributes to the development of standardized protocols for producing high-quality, nutrient-dense functional fermented foods using underutilized agricultural resources.

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3.4. Application and optimization of extrusion technology for the development of soyabean based hybrid meat products, textured protein and meat analogues, and fortified soya-cereal products

- Development of fermented soyabean product (kinema)

Kinema is a traditional, naturally-fermented soybean food of the Eastern Himalayas that relies on a spontaneous microbial consortium dominated by *Bacillus subtilis* and other Firmicutes, which together transform soy proteins, carbohydrates and polyphenols into a range of health-promoting molecules (Kharnaior & Tamang, 2022). The fermentation process generates bioactive peptides through proteolysis, and these peptides exhibit antioxidant, antihypertensive and immunomodulatory activities that depend on the specific strains present (Sanjukta & Rai, 2016). In addition, the microbial community produces flavonoids, isoflavones and exopolysaccharides that contribute to the food's antioxidant and prebiotic properties, underscoring kinema's potential as a functional food ingredient (Kharnaior & Tamang, 2022).

In this study, black soybeans were collected from Lele, Lalitpur, Nepal. The soybeans were then subjected to fermentation for six days. Daily bioactive analyses, including measurements of IC50 values, total polyphenol content, and flavonoid content, were performed to determine the optimal fermentation time. The analysis was performed in triplicate.

The moisture content of Kinema ranged from 60.28% to 66.99%. The bioactive compounds were analyzed daily during a 6-day fermentation period. The total phenolic content increased significantly during fermentation, ranging from 301.21 mg GAE/100g dry matter (DM) at the lowest to 793.36 mg GAE/100g DM at the highest. In comparison, cooked black soybean exhibited a total phenolic content of 173.13 mg GAE/100g DM. Similarly, the total flavonoid content in black soybean Kinema varied from 213.03 mg QE/100g DM to 366.23 mg QE/100g DM, whereas the flavonoid content in cooked black soybean was 214.57 mg QE/100g DM. The IC50 value of Kinema ranged between 4.189 mg/mL and 15.47 mg/mL, indicating enhanced antioxidant activity following fermentation.

These results demonstrate that fermentation significantly increases the bioactive compounds in Kinema, enhancing its antioxidant potential. This observation aligns with the findings of Katuwal *et al.* (2023), that the fermentation duration strongly impacts the bioactive profile of Kinema. Overall, the study highlights the beneficial effect of fermentation in enriching Kinema's bioactive content and potential health-promoting properties.

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3.5. Nutritional and glycemic index properties of high-altitude cereal crops.

The results show a negative relationship between degree of polishing (DoP) and head-rice yield (HRY) (Table 32): as DoP increased from 0 to 10, HRY, while broken rice yield (BRY) increased by a similar margin (Ali et al., 2023)). This highlights that higher polishing intensity significantly reduces whole-kernel recovery. The consistent statistical differences confirm that DoP is a key driver of milling outcome in the Lumle variety. Greater abrasion during polishing increases kernel stress and leading to more breakage, whereas pretreatments like parboiling can mitigate this effect though polishing alone inevitably raises BRY (Ali et al., 2023)

Table 32: Physical property of cereals

S.N	Sample	TKW	Bulk density
1	Lumle	24.86±0.16	637.03±2.38

Values expressed are mean ± standard deviation.

Table 33.: Milling property of Rice

Sample	DoP	HRY (%)	BRY (%)
Lumle	0	86.97±0.87^{a}	13.03±0.87^{e}
Lumle	4	77.72±0.51^{b}	22.28±0.51^{d}
Lumle	6	69.97±0.75^{c}	28.06±3.53^{c}
Lumle	8	66.71±0.98^{d}	31.09±1.09^{b}
Lumle	10	62.70±1.18^{e}	37.30±1.18^{a}

NOTE: DoP: Degree of Polishing. Values expressed are mean ± standard deviation. Values with different letters in the superscripts differ significantly ($p<0.05$).

Table 34: Proximate analysis of different polishing of rice

Sample	DoP	Moisture (%)	Fat (%)	Protein (%)	Ash (%)	Crude fibre (%)	Amylose (mg/100g)
Lumle	0	14.28±0.17^{b}	1.83±0.07^{a}	9.78±0.06^{a}	0.62±0.11^{a}	0.39±0.09^{a}	24806.5±350.06^{a}
Lumle	4	14.17±0.09^{b}	1.80±0.72^{a}	9.57±0.18^{a}	0.41±0.01^{b}	0.26±0.02^{b}	21929.93±303.62^{a}
Lumle	6	14.20±0.01^{b}	1.65±0.04^{b}	9.61±0.14^{ab}	0.39±0.01^{bc}	0.21±0.20^{b}	21629.19±239.87^{a}
Lumle	8	15.73±0.15^{a}	1.20±0.14^{c}	9.19±0.16^{b}	0.36±0.01^{c}	0.15±0.01^{c}	21178.07±331.56^{a}
Lumle	10	15.50±0.08^{a}	0.85±0.20^{d}	8.91±0.20^{b}	0.36±0.01^{c}	0.1±0.01^{c}	19780.28±195.99^{a}

Note: DoP: Degree of Polishing. Values expressed are mean ± standard deviation. Values with different letters in the superscripts differ significantly ($p<0.05$).

Moisture was found to be DoP 6 (~14.2%) but increased significantly at DoP 8–10 (15.5–15.7%). Fat content decreased steadily with increased in polishing (1.83% → 0.85%). Protein content slightly decreased with higher DoP (9.78% → 8.91%). Ash content declined significantly (0.62% → 0.36%), reflecting loss of mineral-rich bran layers during polishing. Fiber decreased (0.39% → 0.10%), consistent with bran removal where most of the dietary fibre resides. Polishing often increases surface exposure and water absorption due to removal of bran and exposure of starchy. This is expected since fat and protein content are highly found in the bran and germ layers, which are removed during polishing (A. O. et al., 2012).

Table 35: Mineral analysis of different polishing of rice.

Sample	DoP	Iron (mg/100g)	Phosphorous (mg/100g)	Sodium (mg/100g)	Potassium (mg/100g)	Calcium (mg/100g)
Lumle	0	1.03±0.17^{a}	220.97±16.81^{a}	4.67±0.58^{a}	470.33±16.58^{a}	29.45±1.97^{a}
Lumle	4	0.61±0.04^{b}	198.43±4.93^{a}	4.36±0.42^{a}	393.22±11.88^{ab}	26.76±1.84^{a}
Lumle	6	0.41±0.05^{bc}	197.05±11.05^{a}	4±0.23^{b}	346.75±6.09^{b}	21.91±2.36^{b}
Lumle	8	0.27±0.03^{c}	110.89±5.89^{b}	3.25±0.2 8^{c}	288.82±10.22^{c}	19.51±2.04^{bc}
Lumle	10	0.17±0.02^{c}	87.82±0.06^{b}	2.1±0.23^{d}	231.56±4.95^{d}	15.52±2.02^{c}

Note: DoP: Degree of Polishing. Values expressed are mean ± standard deviation Values with different letters in the superscripts differ significantly (p<0.05)

Iron content is affected, it falls by ~83% when polishing goes from 0% to 10%. This large drop indicates iron is strongly localized in the bran/outer layers and is removed early in polishing. This pattern is consistent with multiple studies showing large Fe removal with polishing (Sapwarobol et al., 2021). Phosphorus shows fairly stable from 0 → 4 → 6% (220.97 → 197–198 mg/100 g) but drops sharply by 8–10% (to 110.9 and 87.8). That suggests a substantial fraction of P is in the outer aleurone/bran, but a meaningful portion remains in the inner endosperm; only deeper polishing removes it. This agrees with literature reporting that P (and phytic acid) is concentrated in bran/aleurone and often shows a big loss only at higher DOM (Oghbaei &Prakash, 2016). Sodium, potassium and calcium decline linearly, Na and K show roughly 50–55% loss and Ca ~47% loss by 10% DoP. These minerals are partially in outer layers but also distributed into inner grain, producing moderate but still nutritionally important losses. Many reviews note similar moderate-to-large mineral reductions with increased DOM (Bodie et al., 2019)

Table 36: Proximate analysis of different polishing of cooked rice (pressure-cooked)

Sample	DoP	Moisture(%)	Fat(%)	Protein(%)	Ash (%)	Crude fiber (%)	Amylose (mg/100g)
Lumle	0	63.67±0.31^{c}	0.98±0.01^{a}	3.37±0.32^{a}	0.46±0.05^{a}	0.51± 0.02^{a}	7430.25±248.90^{a}
Lumle	4	64.88±0.19^{c}	0.54±0.02^{b}	2.68±0.32^{a}	0.37±0.04^{b}	0.44±0.02^{b}	6687.04±236.17^{b}
Lumle	6	66.32±0.46^{b}	0.44±0.01^{c}	3.23±0.05^{a}	0.30±0.02^{b}	0.38±0.04^{b}	6443.5±226.98^{b}
Lumle	8	67.10±0.33^{b}	0.39±0.01^{c}	2.93±0.04^{a}	0.27±0.02^{bc}	0.30±0.03^{bc}	5956.08±212.13^{b}
Lumle	10	69.86±1.03^{a}	0.33±0.01^{c}	2.74±0.30^{a}	0.18±0.01^{c}	0.09±0.01^{c}	5055.50±352.84^{c}

Note: DoP: Degree of Polishing. Values expressed are mean ± standard deviation. Values with different letters in the superscripts differ significantly (p<0.05).

Moisture increased significantly (P<0.05) with higher DoP (63.67- 69.86%). More polished rice absorbs more water during cooking because the bran and fibre layers that limit hydration are removed, exposing the starchy endosperm (Oko et al., 2012), Fat (0.98 - 0.33%) and fibre (0.51 - 0.09%) content decreased drastically as DoP increased. Fat and fibre content are concentrated in the bran and germ, which are removed during polishing, leading to lower fat in cooked rice. Protein slightly decreased with polishing (3.37 - 2.74%). Proteins are relatively more abundant in the aleurone and outer bran layers, which are progressively removed at higher DoP (A. O. et al., 2012). Ash content decreases significantly (0.46 - 0.18%), reflecting mineral loss. The bran and germ are mineral-rich, so more polishing removes these micronutrients (Oko et al., 2012).

Table 37: Mineral analysis of different polishing of cooked rice (pressure-cooked).

Sample	DoP	Iron	Phosphorous	Sodium	Potassium	Calcium
Lumle	0	1.03±0.17[a]	220.97±16.81[a]	3.91±0.47	82.28±2.51	14.02±1.98
Lumle	4	0.61±0.04[b]	198.43±4.93[a]	3.17±0.27	73.34±3.89	11.31±1.10
Lumle	6	0.41±0.05[bc]	197.05±11.05[a]	2.96±0.17	63.84±2.85	9.73±0.97
Lumle	8	0.27±0.03[c]	110.89±5.89[b]	2.68±0.17	52.50±2.24	9.60±0.66
Lumle	10	0.17±0.02[c]	87.82±0.06[b]	2.05±0.16	44.52±2.21	9.6±0.78

Note: DoP: Degree of Polishing. Values expressed are mean ± standard deviation. Values with different letters in the superscripts differ significantly ($p<0.05$).

Iron content decreases from 1.03 → 0.17 mg/100 g (83.5% loss). Indicating highest iron content was found in the bran and aleurone layers, which are removed during polishing. Cooking further reduces Fe due to leaching into cooking water (Abbas, 2011a). Phosphorous content was significantly ($p<0.05$) stable at 0–6% DoP (~198–220 mg/100 g), but decrease after 8–10% (down to 87.82). Indicates P is partly retained in the endosperm but still higher in outer bran layers. Moderate polishing retains P, but deep milling plus cooking (leaching of phosphate salts) causes major reductions (Oghbaei &Prakash, 2016). Sodium content decrease significantly ($P<0.05$) (3.91 - 2.05 mg/100 g, ~48%). As Na is mostly surface-bound and water-soluble, cooking leads to additional losses. Though rice is not a major sodium source, polishing reduces even trace levels (Abbas, 2011b). Potassium content decrease significantly from (82.28 - 44.52 mg/100 g) (~46% loss). K is highly water-soluble, so cooking contributes significantly to depletion after milling. Loss of K is nutritionally significant because rice is a moderate contributor to K intake (Sudan et al., 2023). Calcium content was found to be significantly ($P<0.05$) decreasing (~31% loss, 14.02 - 9.6 mg/100 g). Ca is partly found in bran but also bound in the grain matrix, hence less sensitive to polishing compared to Fe and P. Some Ca is retained even in polished cooked rice, but still lower than brown rice (Sudan et al., 2023).

Table 38: Proximate analysis of different polishing of Cooked rice (Rice cooker)

Sample	DoP	Moisture (%)	Fat (%)	Protein (%)	Ash (%)	Crude fiber (%)	Amylose (mg/100g)
Lumle	0	64.91±1.11^{b}	0.94±0.03^{a}	3.87±0.10^{a}	0.44±0.08^{a}	1.10±	7264.50±198.69
Lumle	4	66.83±0.53^{a}	0.44±0.01^{b}	3.08±0.05^{b}	0.36±0.02^{ab}	0.70±0.35^{b}	6707.50±40.71
Lumle	6	67.89±0.47^{a}	0.37±0.02^{c}	2.88±0.02^{bc}	0.26±0.02^{bc}	0.39±0.04^{c}	6126.50±151.25
Lumle	8	67.96±0.89^{a}	0.33±0.01^{cd}	2.50±0.34^{c}	0.22±0.01^{c}	0.25±0.04^{d}	5655±210.71^{c}
Lumle	10	68.64±0.19^{a}	0.29±0.01^{d}	2.46±0.09^{c}	0.17±0.01^{c}	0.14±0.06^{d}	5004.50±424.97

Note: DoP: Degree of Polishing. Values expressed are mean ± standard deviation. Values with different letters in the superscripts differ significantly ($p<0.05$).

Moisture increased significantly ($P<0.05$) with higher DoP (64.91 - 68.64%). The higher the DoP, higher will be water during cooking because the bran and fibre layers that limit hydration are removed, exposing the starchy endosperm (A. O. et al., 2012). Fat (0.94 - 0.29%), Protein (3.37 - 2.74%), fiber (1.10 - 0.14%) and Ash content (0.44-0.17%) decrease significantly ($P<0.05$) while increase in DoP. Bran and germ layer contain high amount of fat, protein and rich in minerals and fiber (Oko et al., 2012). Hence, leading the result towards lower fat, protein, ash and fibre when increase in DoP.

Table 39: Minerals analysis of different polishing of rice.

Sample	DoP	Iron	Phosphorous	Sodium	Potassium	Calcium
Lumle	0	1.10±0.05^{a}	221.06±19.79^{a}	3.97±0.37	84.12±2.87	14.09±1.92
Lumle	4	0.70±0.35^{b}	193.56±12.02^{a}	3.68±0.63	72.41±3.22	12.61±1.36
Lumle	6	0.39±0.04^{c}	157.04±9.93^{b}	2.99±0.36	66.02±0.10	10.15±0.47
Lumle	8	0.25±0.04^{d}	122.05±8.47^{c}	1.97±0.31	63.03±1.58	9.16±0.86^{c}
Lumle	10	0.14±0.06^{d}	92.83±3.92^{b}	1.89±0.34	61.45±0.86	8.89±1.17^{c}

Note: DoP: Degree of Polishing. Values expressed are mean ± standard deviation. Values with different letters in the superscripts differ significantly ($p<0.05$).

Iron content, Phosphorous content, Sodium content Potassium content and calcium content was significantly (0.05) low while increase in Dop and found to be 1.10 → 0.14 mg/100 g, ~192–221mg/100 g, 3.97→ 1.89 mg/100 g, 84.12 → 61.45 mg/100 g and 14.09 → 8.89 mg/100 g. Indicating highest minerals content was found content was found in the bran layers, which are removed during polishing. Cooking further reduces Fe due to leaching into cooking water (Abbas et al., 2011). Moderate polishing retains P, but higher milling and cooking (leaching of phosphate salts) causes major reductions (Oghbaei &Prakash, 2016). Na is mostly surface-bound and water-soluble, and decrease more while cooking. Though rice is (Abbas et al., 2011). Ca is partly contained in bran but also bound in the grain matrix, making it less sensitive to polishing than Fe and P. Even polished cooked rice has some Ca, but it remains lower than brown rice (Sudan et al., 2023).

Table 40: Proximate analysis of different polishing of cooked rice (pan-cook)

Sample	DoP	Moisture(%)	Fat(%)	Protein(%)	Ash (%)	Crude fiber	Amylose (mg/100g)
Luml	0	61.83±0.3	0.93±0.1	4.13±0.0	0.44±0.0	1.10±	6458.04±12.
Luml	4	63.04±0.0	0.54±0.0	3.05±0.0	0.36±0.0	0.70±0.	6103.08±13.
Luml	6	63.26±1.0	0.48±0.0	2.96±0.0	0.26±0.0	0.39±0.	5844.02±48
Luml	8	63.76±1.0	0.41±0.0	2.68±0.0	0.22±0.0	0.25±0.	5345.05±27.
Luml	10	65.73±0.3	0.32±0.0	2.44±0.2	0.17±0.0	0.14±0.	4445.50±19.

Note: DoP: Degree of Polishing. Values expressed are mean ± standard deviation. Values with different letters in the superscripts differ significantly (p<0.05).

Moisture was found to be significantly (P<0.05) with higher DoP (61.83 - 65.73%). More polished rice absorbs more water while cooking because the bran and fiber layers that inhibit hydration are removed, exposing the starchy endosperm (Oko et al., 2012). Fat, Fiber, Protein, Ash and Amylose content was significantly low while increase in DoP and found to be in the range of 0.93 - 0.32%, 0.93 - 0.32%, 4.13 - 2.44%, 0.44 - 0.17% and Bran and germ layers have a large amount of fat, protein, amylose and minerals, resulting in decreasing fat, protein, ash, and fibre levels as DoP increases (Oko et al., 2012).

Table 41: Mineral analysis of different polishing of rice.

Sample	DoP	Iron (mg/100g)	Phosphorous (mg/100g)	Sodium (mg/100g)	Potassium (mg/100g)	Calcium (mg/100g)
Lumle	0	$1.03±0.17^{a}$	$220.97±16.81^{a}$	3.19±0.52	62.11±2.78	12.45±2.32
Lumle	4	$0.61±0.04^{b}$	$198.43±4.93^{a}$	2.40±0.67	54.54±2.23	10.37±1.02
Lumle	6	$0.41±0.05^{bc}$	$197.05±11.05^{a}$	2.09±0.95	47.09±2.12	9.57±1.52
Lumle	8	$0.27±0.03^{c}$	$110.89±5.89^{b}$	1.70±0.63	38.89±2.75	8.43±0.02
Lumle	10	$0.17±0.02^{c}$	$87.82±0.06^{b}$	1.16±0.60	34.29±2.18	8.21±0.58

Note; DoP: Degree of Polishing. Values expressed are mean ± standard deviation. Values with different letters in the superscripts differ significantly (p<0.05).

Iron content, Phosphorous content, Sodium content Potassium content and calcium content was significantly (0.05) low while increase in Dop and found to be 1.03 → 0.17 mg/100 g, 87.82–220mg/100 g, 3.19→ 1.16 mg/100 g, 62.11 → 34.29 mg/100 g and 12.45→ 8.21 mg/100 g. Highest mineral richness was observed in the bran layers, which were eliminated during polishing. Cooking further decreases Fe by leaching into cooking water (Abbas et al., 2011). Moderate polishing preserves P, while higher milling and boiling (phosphate salt leaching) results in significant decreases (Oghbaei &Prakash, 2016). Na is largely surface-bound and water-soluble; it decreases more during cooking (Abbas et al., 2011). Ca is partially included in bran but also bound in the grain matrix, hence it is less sensitive to polishing than Fe and P. Even polished cooked rice has some calcium, but it is lower than brown rice (Sudan et al., 2023).

Scanning Electron Microscopy

Introduction

The Scanning Electron Microscope (SEM) is mostly used to observe specimen surfaces. When a specimen is bombarded with a fine electron beam (known as an electron probe), it emits secondary electrons from the surface. SEM creates highly magnified images of surface topography by scanning this probe two-dimensionally across the object and measuring the secondary electrons released. This allows for more detailed analysis of surface morphology and microstructures than light microscopes do. (Technology, n.d.).

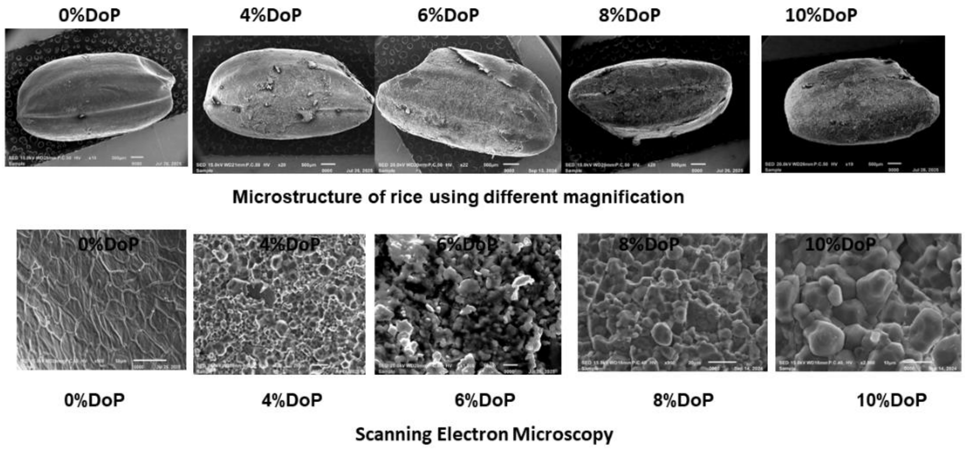

Figure 2. Scanning Electron Microscopy picture of rice at different degree of polishing

0%DoP

The intact aleurone layer with cuboidal cells (3-5 cell thick), polygonal starch granules (3-8 μm) are visible, densely packed but distinct boundaries, and protein bodies (0.5–2.5 μm) in the endosperm indicates a nutrient-rich structure with preserved proteins, lipids, and minerals (Mohapatra &Bal, 2007)

4-6%DoP

At 4–6% DoP, partial removal of the aleurone layer exposes starch granules and reduces protein bodies, leading to moderate nutrient loss but still retaining appreciable nutrition and cooking quality (Mohapatra &Bal, 2007)

8-10%DoP

At 8–10% DoP, the aleurone layer is mostly removed, only inner endosperm remains, leaving compact and uniform starch-rich endosperm with few protein bodies, causing significant nutrient loss (Mohapatra &Bal, 2007).

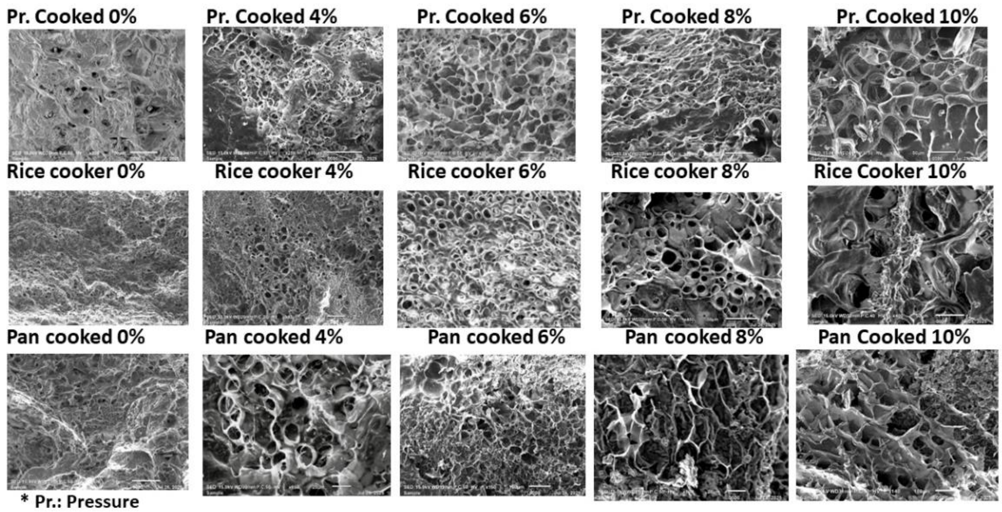

Figure 3. Scanning Electron Microscopy picture after cooking of rice at different degree of polishing

At 0% polishing (brown rice), the bran and aleurone layers are intact, resulting in a rough microstructure that resists water penetration. This results in a tougher texture and longer cooking time, but also increases dietary fiber, minerals, and bioactive substances. At 4-6% polishing, partial bran removal exposes starch granules and creates microcracks. This facilitates more efficient water absorption and gelatinization, resulting in a more balanced texture while preserving some nutrients.At 8-10% polishing, SEM shows a smooth, starch-rich surface with almost no bran, resulting in homogeneous gelatinization and a soft, sticky texture. However, the nutritional value declines as bran-associated elements are lost (Peng et al., 2021).

Pressure cooking method increases the starch gelatinization, as evidenced by ruptured granules, resulting in soft, cohesive rice but with potential heat-sensitive nutritional losses.Rice cooker cooking produces moderate, homogeneous gelatinization, retaining structural integrity while striking a healthy balance between softness and nutrient preservation.Pan heating causes incomplete gelatinization, which appears as partially inflated granules, giving rice a tougher, less uniform texture while preserving certain nutrients due to less thermal deterioration.

Chemical Analysis of Millet

Table 42: Chemical analysis of Millet

Sample	Moisture (%)	Fat (%)	Protein (%)	Ash (%)	Crude fibre (%)	Iron (mg/100g)	Phosphorous (mg/100g)	Amylose (mg/100g)
Raw	10.53±0.12[b]	1.89±0.08[a]	8.62±0.04[a]	2.36±0.09[a]	5.38±0.08[a]	4.16±0.09[a]	296.61±2.74[a]	19802.52±11.12
Cooked	69.49±0.01[a]	0.97±0.04[b]	2.90±0.01[b]	0.84±0.05[b]	1.05±0.04[b]	2.59±0.15[b]	130.18±11.71[b]	6690.88±17.60[b]

Values expressed are mean ± standard deviation.
Values with different letters in the superscripts differ significantly ($p<0.05$).

Cooking increases water absorption, leading to grain swelling and dilution of nutrients compared to uncooked millet. Protein & Fat were significantly ($P<0.05$) decreased, but this is mostly dilution. Cooking also causes protein denaturation (increasing digestibility) and lipid oxidation (lowering antioxidant activity) (Saleh et al., 2013). The decrease in crude fibre indicates cooking soften texture, improving palatability but lowering fibre benefit. Iron and phosphorus content significantly ($P<0.05$) decrease while cooking due to the leaching into cooking water. Amylose content significantly ($P<0.05$) reduced after cooking due to starch gelatinization which disrupts crystalline structure, reducing extractable amylose content (Saleh et al., 2013).

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4. Documentation, Standardization, and Optimization of Ethnic Food of Nepal

4.1. Standardization of *thon* processing technology and Optimization of broken rice percentage for the best sensory quality

Murcha (traditional starter culture) samples were collected from six sites across the Kathmandu Valley: Basantapur, Balambu, Chitrapur, Purano Thimi, Dakshinkali, and Kirtipur, although samples from Dakshinkali and Kirtipur were discarded due to unsuitability. Fermentation was conducted in small batches using approximately 300 g of steamed rice inoculated with 3 g of murcha at 28 °C. The process began with a 2-day aerobic phase in conical flasks, followed by 3–18 days of anaerobic fermentation. Samples were collected every three days (days 3, 6, 9, 12, 15, and 18) to monitor changes in chemical attributes, including alcohol content, and assess the effectiveness of the starter cultures. The resulting data were statistically analysed using a full factorial model in IBM SPSS Statistics (Version 26.0, IBM Corp., USA).

Alcohol Content: Alcohol content increased significantly to a peak by Day 9-12 before declining slightly by Day 18. The interaction between samples and time was also significant. This pattern reflects typical fermentation, where microorganisms in *murcha* break down starch into ethanol and contribute to aroma formation (Nout & Aidoo, 2002; Suprianto et al., 1989). The results confirmed that the observed variations reflect meaningful changes over time, consistent with traditional fermentation methods (Pakuwal & Manandhar, 2020).

Acidity as lactic acid: Lactic acid levels increased significantly over time and between samples, peaking around Days 12-15. This indicates active lactic acid bacteria (LAB) growth, which enhances flavor complexity, consistent with their role in traditional fermentations.

Table 43: Physicochemical analysis of the *thon* sample from day 3 to day 18.

Sample	Days	Alcohol%	Acidity as lactic acid	Volatile acidity (m/m%)	Ester content (m/m%)	pH
BP	3	4.27±0.75^{k}	0.45±0.02^{l}	0.33±0.009^{c}	0.19±0.05^{h}	3.7±0.04^{f}
	6	7.61±0.25^{fg}	0.65±0.007^{f}	0.18±0.25^{gh}	0.48±0.009^{a}	3.8±0.04^{e}
	9	9.00±1.79^{d}	0.74±0.01^{b}	0.36±0.06^{bc}	0.43±0.06^{b}	3.9±0.00^{d}
	12	5.33±0.37^{ij}	0.84±0.01^{a}	0.55±0.47^{a}	0.04±0.17^{l}	4.05±0.01^{c}
	15	6.283±0.25^{h}	0.55±0.01^{i}	0.37±0.02^{b}	0.40±0.17^{c}	4.05±0.0^{c}
	18	5.85±0.57^{hi}	0.70±0.27^{de}	0.37±0.13^{b}	0.30±0.02^{ef}	3.9±0.01^{d}
PT	3	5.04±0.12^{j}	0.34±0.005^{n}	0.25±0.18^{de}	0.12±0.11^{i}	3.7±0.05^{g}
	6	10.77±0.06^{b}	0.56±0.009^{i}	0.19±0.009^{fg}	0.11±0.00^{ij}	3.8±0.01^{e}
	9	12.85±0.75^{a}	0.66±0.007^{f}	0.04±0^{mn}	0.17±0.00^{h}	3.93±0.00^{d}
	12	9.23±0.51^{d}	0.49±0.12^{k}	0.06±0.14^{lm}	0.34±0.022^{d}	4.03±0.00^{c}
	15	8.41±0.07^{e}	0.49±0.11^{k}	0.06±0.10^{lm}	0.28±0.15^{ef}	3.93±0.00^{d}
	18	4.07±0.12^{k}	0.44±0.006^{l}	0.12±0.13^{ij}	0.091±0.14^{jk}	3.83±0.01^{e}
CP	3	6.19±0.12^{h}	0.41±0.006^{m}	0.22±0.00^{ef}	0.59±0.16^{kl}	3.6±0.02^{h}
	6	10.59±0.11^{b}	0.53±0.009^{j}	0.19±0.00^{fg}	0.07±0.012^{kl}	3.93±0.04^{d}
	9	12.04±0.11^{b}	0.62±0.006^{h}	0.17±0.01^{gh}	0.27±0.019^{ef}	4.03±0.01^{c}
	12	13.13±0.65^{a}	0.70±0.19^{d}	0.14±0.00^{hi}	0.12±0.012^{ij}	4.17±0.013^{a}
	15	9.14±0.065^{d}	0.68±0.01^{e}	0.10±0.01^{jk}	0.33±0.15^{de}	4.06±0.02^{c}
	18	6.33±0.12^{h}	0.69±0.10^{de}	0.08±0.00^{kl}	0.34±0.035^{d}	3.93±0.02^{d}
B	3	5.42±0.18^{ij}	0.35±0.008^{n}	0.22±0.00^{f}	0.05±0.03^{kl}	3.72±0.02^{g}
	6	7.03±0.11^{g}	0.56±0.01^{i}	0.17±0.00^{gh}	0.06±0.02^{kl}	3.80±0.01^{ef}
	9	7.82±0.54^{f}	0.63±0.02^{g}	0.16±0.10^{gh}	0.11±0.04^{ij}	3.91±0.02^{d}
	12	7.46±0.21^{fg}	0.72±0.01^{c}	0.34±0.11^{bc}	0.09±0.02^{ijk}	4.05±0.01^{c}
	15	7.12±0.80^{g}	0.48±0.12^{k}	0.27±0.00^{d}	0.32±0.09^{de}	4.08±0.10^{b}
	18	7.50±0.28^{fg}	0.69±0.03^{de}	0.02±0.00^{mn}	0.25±0.03^{g}	3.93±0.02^{d}

*Values are the means of the triplicates and the standard deviation. Means in the row with different superscripts are significantly at $p < 0.05$.

Volatile Acidity: Significant differences in volatile acidity were observed across both sample types and fermentation time ($p < 0.05$), with concentrations fluctuating and reaching peak levels around Day 12. These volatile acids play a key role in shaping the aromatic profile of fermented beverages; however, elevated concentrations can lead to undesirable sensory characteristics. It is therefore essential to regulate these levels to ensure product quality and consumer acceptance, particularly in traditional fermented beverages such as those produced in Nepal (Boulton et al., 1996).

Ester Content: Ester levels varied significantly ($p < 0.05$), peaking early on Day 3 before declining. These compounds provide crucial fruity and floral aromas, but their reduction over time is likely due to hydrolysis or changing yeast activity which significantly influences the beverage's evolving sensory profile (Thapa and Tamang, 2006).

pH: pH increased gradually, showing significant differences ($p<0.05$) between early and later fermentation days. CP (4.17 at day 12**)** had the highest value, likely due to buffering by accumulated metabolites. After day 12, pH changes were not significant, indicating system stabilization.

- Optimization

The optimization using a multiple regression model resulted in the best Murcha and fermentation time for optimal physiochemical quality were determined to be murcha from B(Balambu) and 5.52 days, respectively. The optimal desirability of the model was 0.70 with 95% confidence interval (CI) of the physiochemical parameters, pH, alcohol (%), Total acidity (%), volatile acidity (%m/m), ester content (%m/m) were in the range of3.78-3.82,7.87-9.97, 0.49-0.58, 0.0964-0.201, 0.213-0.324, respectively (Fig 4.2, 4.3) producing moderate but sufficient alcohol levels within a shorter time, while maintaining relatively low levels of total acidity and volatile acidity. The ester content remained within an acceptable range for sensory quality, and the pH stabilized around the target value of 3.8. These characteristics suggest that *Murcha B* promotes efficient and controlled fermentation, making it the most suitable starter culture for achieving desirable product quality in a reduced fermentation time**.**

Table 44: The proximate analysis of the head rice and broken rice was evaluated.

Parameters	**BR (broken rice)**	**HR (head rice)**
Moisture content (%)	12.63 ± 0.98^a	12.68 ± 0.19^a
Crude protein (%)	9.56 ± 0.60^a	8.47 ± 0.33^a
Total ash (%)	0.31 ± 0.15^a	0.26 ± 0.13^a
Crude fat (%)	1.03 ± 0.71^a	0.81 ± 0.08^a
Crude fiber (%)	0.11 ± 0.004^a	0.25 ± 0.41^b

*****Values are the means of the triplicates and standard deviation. Means in the row with different superscripts are significantly at $p < 0.05$.

The statistical analysis showed that the values of Moisture content, Protein content, Total Ash content, and Crude fat content of broken rice and head rice did not differ significantly ($p>0.05$). The crude fibre content was statistically different. DFTQC (2012) reported moisture content, crude protein, ash, crude fat, crude fibre, and of rice to be 13.7%, 6.8%, 0.2%, 0.5%, 0.6% respectively.

The best proportion of broken rice and head rice was determined using a mixture design. The design of experiment (DOE) was done using a simplex centroid mixture design for two components, broken rice (-1:0 %,0: 50 %, and +1: 100) and head rice (-1:0, 0:50% and +1: 100) using Minitab Statistical Software. The five experimental runs thus developed were subjected to the best fermentation time, determined by multiple experiments from previous studies, and then analyzed physico chemically and evaluated by sensory panels of 23 panelists.

The best broken rice percentage was determined using response optimizer with best sensory parameters as response (higher aroma, higher color, higher taste, lower sourness, higher mouthfeel, and higher overall acceptability).

Table 45: Determination of the best proportion of broken rice for *Thon*

Run	Head rice	Broken rice
1	75	25
2	50	50
3	25	75
4	100	0
5	0	100

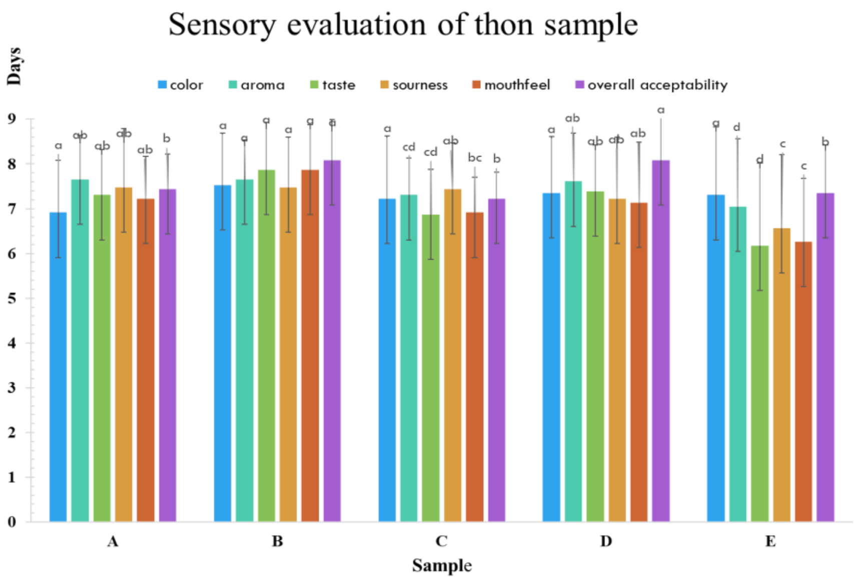

Figure 4. Sensory evaluation of thon sample

The sensory evaluation resulted that Sample B was the most preferred, with consistently high scores across all attributes. Samples A and D also performed well, while Sample C had moderate ratings. Sample E received the lowest scores, particularly in taste, sourness, and mouthfeel.

Optimization of sensory evaluation.

The optimization, using a multiple regression model resulted that 33.33% of broken rice can be utilized for *Thon*, indicating that this proportion provided the best overall sensory performanceThe optimal desirability of the model was 0.75 with 95% confidence interval (CI) of the sensory parameters, aroma, taste, sourness, mouthfeel was in the range of 7.33-7.77,7.28-7.95,7.23-7.90,7.24-7.86 respectively (Fig 3).

The criteria were set to achieve the highest possible scores for aroma, taste, sourness, and mouthfeel simultaneously. This optimized level represents a balance point where all desirable sensory qualities were maximized, supporting the effective use of broken rice in product development without compromising sensory acceptability.

Table 46: Physicochemical analysis of *thon* samples of different head rice and broken rice composition.

Parameters	A(1)	B(2)	C(3)	D(4)	E(5)
TSS	9	10	8	11	9
Alcohol (%)	8.14	8.69	8.55	9.223	8.01
Acidity as lactic acid	0.57±0.022c	0.65 ±0.01b	0.701± 0.04a	0.45± 0.02d	0.44±0.005d
Volatile acidity (%m/m)	0.11±0.038ab	0.14±00a	0.154±00a	0.05±00c	0.07 ±0.03bc
Ester content (%m/m)	0.06±0.021ab	0.087±0.01a	0.075±0.01ab	0.63± 0.01ab	0.43± 000b
Aldehyde content	0.04 ±00b	0.03±0.002c	0.043±0.005b	0.056±0.005a	0.059 ±004a
Reducin gsugar	4.77 ± 0.10a	3.03± 0.25c	1.038 ±0.01d	4.24± 0.29b	0.20±0.002e
Final pH	3.96 ±0.07b	3.79±0.005c	3.93±0.051b	3.94±0.052b	4.15±0.051a

*****Values are the means of the triplicates and the standard deviation.

Acidity as lactic acid

Sample C stood out with the highest acidity (0.701% acetic acid), which was significantly higher than the others. This explains its stronger sour taste, likely noticed by panellists during sensory testing (Joshi et al., 2017; Steinkraus, 2002). In contrast, samples D and E had much lower acidity (~0.45%), indicating a milder, smoother sourness.

Volatile acidity

Regarding volatile acidity, samples B and C had higher levels (around 0.15%), resulting in a sharper, more pungent flavour, while sample D had the lowest, contributing to a gentler taste.

Ester and aldehyde content

Esters, which give fruity and pleasant aromas, were highest in sample B and significantly different from sample E, with samples A, C, and D falling in between. This likely explains why sample B was rated better in aroma during the sensory tests (Gupta & Sharma, 2020; Zheng et al., 2019). Aldehyde levels were notably higher in samples D and E, which can add complexity to the aroma, although too much might cause off-flavours (Jia et al., 2018).

Reducing sugar

Regarding reducing sugars, sample A retained a significantly higher amount of leftover sugar, indicating fermentation was less complete compared to the other samples. Conversely, sample E had very little residual sugar, suggesting microbes consumed most sugars (Li et al., 2015).

pH

The pH results also revealed a pattern: sample E had the highest pH (less acidic), while sample B had the lowest pH, confirming it was the most acidic sample. This aligns with the sensory perceptions of sourness (Tamang, 2010; Joshi et al., 2017).

Table 47: Physicochemical analysis of alcohol from different locations

S.N	Sample	Alcohol	Acidity as acetic acid(g/l)	Volatile acidity(g/100l)	Ester content (g/100l)
1	Khokim, Pashupatinagar	18.12±.006[j]	0.110±0036[e]	58.46±1.91[e]	197.38±11.20[c]
2	Laligurans, Pashupatinagar	22.75±.01[f]	0.110±0.37[e]	45.71±15.45[f]	180.51±8.93[c]
3	Syal ko raksi,Illam	20.58±0.2[h]	0.533±0.033[b]	226.43±14.38[a]	344.93±4.93[b]
4	*Gahu* ko raksi, Pashupatinagar	19.11±0.4[i]	0.164±0.0[d]	75.01±0.577d	95.16±5.31[d]
5	Kiwi, Illam	45±0.3	0.64±0.007[a]	139.55±1.53[c]	453.68±0.0a
6	Banana ,Illam	37.83±0.2[d]	0.094±0.003[e]	24.31±0.91f	48.07±7.10e
7	KMR, NARC	43±0.1[b]	0.115±0.003[e]	26.04±0.80f	76.40±2.36de
8	KMR, NARC	45±0.2[a]	0.177±0.003[d]	38.22±0.769[e]	92.56±4.51[d]
9	Millet Malt Byproduct, NARC	42.3±0.5[c]	0.119±0.007[e]	13.71±0.81fw	102.63±35.3[d]

*Values are the means of the triplicates and the standard deviation

Alcohol Content: The final alcohol concentration is primarily a function of the initial fermentable sugar content and the efficiency of yeast in converting sugars to ethanol under anaerobic conditions (Walker & Stewart, 2016). Kiwi (45%) and KMR (45%) exhibited the highest alcohol levels. This can be attributed to the very high sugar content of kiwi fruit and the use of a high-yield, modern yeast strain (likely in the KMR samples), which efficiently completed fermentation. The lower alcohol in traditional samples suggested the use of mixed cultures with non-*Saccharomyces* yeasts that may have lower ethanol yields or incomplete fermentation due to early nutrient depletion (Tamang, 2010).

Acidity (as Acetic Acid): High acidity is observed in Kiwi alcohol (0.64 g/l) and Syal ko Raksi (0.533 g/l), originating from the raw material's natural fruit acids and metabolic activity by Lactic Acid Bacteria (LAB) during fermentation (Liu, 2002). LAB produces lactic acid, which sharpens the sensory profile and improves microbial stability. The low acidity in Banana alcohol (0.094 g/l) indicates minimal bacterial activity or a different acid profile in the base ingredient.

Volatile Acidity (VA): VA is predominantly acetic acid, a major spoilage compound produced by Acetic Acid Bacteria (AAB) when ethanol is exposed to oxygen (Boulton et al., 1996). The extremely high VA in Syal ko raksi (226.43 g/100l) is a clear indicator of post-fermentation oxidation or contamination, imparting a strong vinegar-like off-flavour. The low VA in banana alcohol and KMR determined careful, anaerobic handling during and after fermentation, preserving the ethanol content and producing a cleaner product.

Ester Content: Esters are key aroma compounds formed by yeast through esterification reactions between alcohols and acids during fermentation (Siebert et al., 2005). The high ester content in Kiwi alcohol (453.68 g/100l) is characteristic of fruit fermentations, which provide a diverse array of precursor acids and alcohols, resulting in intense fruity aromas. The lowest ester levels in grain-based samples suggest less prolific ester-producing conditions or yeast strains.

The study standardized Thon fermentation using murcha from Kathmandu Valley and optimized broken rice proportion for quality. Alcohol peaked at days 9–12 (up to 13.1%), then declined, while lactic acid rose steadily, confirming LAB activity. Volatile acidity fluctuated, peaking around day 12, esters were highest early, and pH gradually increased before stabilizing. Optimization identified Balambu murcha as the best starter and ~5.5 days as the optimal fermentation period, with 33% broken rice producing the best sensory profile. Regional alcohol analysis showed Kiwi and KMR had the highest ethanol and ester levels, while traditional raksi had lower alcohol but higher volatile acidity.

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4.2. Exploration into different alcoholic beverages from different locatoins

- **Introduction**

Nepal is rich in ethnic and indigenous alcoholic beverages, deeply rooted in cultural practices and traditions across diverse ethnic groups. These traditional alcoholic products, crafted from locally grown cereals like millet and rice, showcase a unique blend of indigenous knowledge and fermentation science, making significant contributions to Nepal's socio-economic and cultural landscape. The primary beverages, *jand*, *tongba*, *nigar*, and *raksi*, are prepared using specific cereal substrates, traditional fermentation starters like *murcha*, and distinct processing methods passed down through generations. Each beverage serves not only as a symbol of heritage but also plays an integral role in ethnic rituals, ceremonies, and communal gatherings, reflecting the culinary artistry and sustainable agricultural practices of Nepalese communities.

Among the core ingredients, millet, particularly finger millet (*Eleusine coracana*), plays a pivotal role. Occupying over 267,000 hectares, finger millet is Nepal's fourth most important crop, thriving in both mid- and high-hill regions and serving as a staple for direct consumption and traditional brewing (MoALD 2023). The brewing process for millet-based alcoholic beverages, such as *jand*, *tongba*, and *raksi*, involves traditional fermentation techniques that enhance the nutritional profile of these cereals, making them culturally significant foods and potential sources of health benefits. Traditional fermentation enriches these beverages with essential nutrients and bioactive compounds, adding to their sensory appeal and therapeutic qualities.

For example, *jand* and *raksi* are integral to Newar, Limbu, Tamang, and Rai cultures. *Jand*, a sweet-sour cereal beer, is typically prepared by fermenting finger millet, rice, wheat, or maize with *murcha* as a fermentation starter. At the same time, *raksi* is a distilled spirit obtained through pot distillation. Both beverages are central to ethnic rituals and are often offered to guests as symbols of hospitality. Additionally, *tongba*, made by fermenting millet in bamboo or wooden containers, is popular among Himalayan communities and is consumed at festivals and social gatherings. The preparation methods of these beverages vary based on geographical, cultural, and environmental factors, creating diverse products with unique sensory profiles across Nepal.

Jandh (Chhyang or Toongba or Poko) and *Rakshi* are the major alcoholic fermented liquor traditionally consumed in various parts of Nepal, depending Murcha (yeast) starters are common for the necessary fermentation to produce these products in Nepal, some parts of India and southeast China. On the availability of the raw materials. . Rakshi, an unaged congeneric spirit, is obtained through pot distillation of fermented cereal slurry or mash, showcasing varying alcohol contents (15-40% v/v). Raksi unfolds through a meticulous distillation process of fermented mash, jand. These alcoholic beverages are prepared using different substrates as millet, rice and wheat.

The starters, *murcha* in Nepal and India, Luck pang in Thailand, Ragi in Indonesia, Bubod in Philippines, Nurok in Korea and Chiu-Yueh or Peh-yeh in China. Murcha is a Nepali word; the Lepchas (one ethnic group) use the word Thamik, and the Limbu (other ethnic groups of Nepalese) use Khesung. Trade in Murcha is protected as a hereditary right of certain castes of the Nepalese (particularly Limbu and Rai) and the Lepchas. The Murcha starter cakes are of two types, Manapu and Mana. The Manapu is prepared from rice flour and millet grains, whereas the Mana is prepared from wheat flakes. Murcha quantities are contingent upon fermentation temperature and intended product, with reduced murcha favored for tongba and elevated concentrations beneficial for jand, Raksi production advocates the highest murcha content, occasionally introduced a few days before completion for increased yield and strength.

The fermentation techniques used in these traditional products not only enhance flavor but also improve the nutritional value of the cereals. The metabolic transformations during fermentation increase the bioavailability of nutrients and bioactive compounds, resulting in products with potential health benefits. For example, *tongba* contains significant levels of antioxidants, which may support high-altitude health by combating oxidative stress. Similarly, *raksi* and *jand* have complex microbial dynamics involving lactic acid bacteria, yeasts, and molds, contributing to distinctive flavor and nutrient profiles and exemplifying the scientific richness of Nepal's indigenous fermentation practices.

Despite their cultural significance, traditional Nepalese alcoholic beverages face challenges related to standardization, commercialization, and cultural heritage preservation. Research on these beverages is essential to ensure quality control, enhance production efficiency, and expand their market potential both locally and globally. A scientific understanding of the fermentation process and microbial dynamics presents an opportunity to refine these traditional products, providing economic opportunities for rural communities while preserving the cultural legacy of Nepal's indigenous alcoholic beverages.

The range of alcohol (%), total acidity(g/100l), volatile acidity(g/100l), ester content(g/100l) and aldehyde content (g/100l) were found to be 8.6-22.8,1.98-7.12,4.15-9.76,15.09-39.65 and 9.19-29.26.

Table 48: Chemical analysis of alcoholic beverage.

Location	Alc (%)	TA	VAAA	EEA	Aldehyde
Chitlang millet (CH)	10±0.11^{h}	1.98±0.0007^{f}	4.6±0.043^{f}	16.36±0.007^{h}	16.33±0.008^{d}
Shilgadi, doti rice (SG)	17.4±0.0^{d}	2.48±0.001^{e}	6.4±0.063^{c}	29.36±0.001^{e}	13.32±0.67^{f}
Mandandeupur millet a(MP)	18.4±0.0^{c}	5.09±0.93^{b}	6.74±0.055^{c}	30.41±0.04^{c}	9.19±0.001^{g}
Mandandeupur millet b (MB)	22.8±0.11^{a}	7.12±0.023^{a}	9.76±0.08^{a}	39.65±0.006^{a}	24.56±0.56^{b}
Nuwakot strawberry brandy (NK)	20.73±0.11^{b}	6.92±0.51^{a}	8.12±0.55^{b}	35.32±0.075^{b}	29.26±0.53^{a}
Dhanpokhari, lamjung millet (DP)	12.73±0.11^{f}	3.48±0.49^{d}	5.41±0.50^{de}	25.43±0.059^{f}	17.19±0.15^{c}
Chyangritar, Gorkha (CG)	8.6±0.0^{i}	2.76±0.69^{e}	4.15±0.17^{f}	15.09±0.001^{i}	15.77±0.024^{e}
Pokhara, begnas millet (BP)	10.4^{g}	2.42±0.06^{e}	4.76±0.11^{ef}	20.13±0.001^{g}	16.81±0.05^{c}
Inaruwa rice (IR)	15.4±0.0^{e}	4.59±0.05^{c}	5.68±1.14^{d}	30.24±0.23^{d}	29.62±0.29^{a}

**Note:Alc= Alcohol, TA= Total acidity (% m/v) as acetic acid, VAAA= Volatile acidity as acetic acid, EEA= Ester as ethyl acetate*

$^{a-i}$ Values with different letters in the superscripts differ significantly($p < 0.05$)

Values presented are means ± SD of triplicate values.

- **Alcohol Content Variation**

Analysis across nine alcoholic samples from diverse Nepalese regions, including Chitlang, Mandandeupur, Nuwakot, and Dhanpokhari, revealed significant differences in alcohol concentration. The Chyangritar, Gorkha sample (CG) had the lowest (8.6%) alcohol content whwreas, the Mandandeupur millet sample (MB) had the highest (22.8%). This variation reflects the impact of local fermentation practices, substrates, and environmental factors. Higher alcohol levels, as seen in Mandandeupur millet, correlate with elevated fermentation temperatures, while lower levels, such as those in Chyangritar, are associated with cooler conditions (Knoll et al., 2011).

- **Acidity Profiles**

Total acidity as acetic acid differed significantly across samples, ranging from 1.98% in Chitlang millet (CM) to 7.12% in Mandandeupur millet (MB). These values indicate differences in microbial activity and fermentation conditions, where high acidity levels are often attributed to the breakdown of free sugars by lactic acid bacteria and yeasts (Tamang & Thapa, 2006).

- **Volatile Acidity and Ester Content**

Volatile acidity levels varied from 4.15% to 9.76%, with the Mandandeupur millet sample showing the highest level. Ester content, particularly ethyl acetate, was notably higher in Mandandeupur millet (39.65%) than in other samples, reflecting its extended fermentation and maturation processes, which promote ester formation. Chyangritar's sample, however, had a notably low ester content, linked to its reduced volatile acidity and alcohol percentage (Deng et al., 2020).

- **Aldehyde Concentrations**

Aldehyde levels, an indicator of flavor and aroma quality, ranged from 9.19% to 29.26%. Significant difference was observed statistically between samples Mandandeupur millet (MP) and Inaruwa rice Samples from Nuwakot strawberry brandy (NB) and Inaruwa rice (IR) contained the highest aldehyde levels, suggesting that both the substrate variety and local fermentation techniques influence aldehyde formation, affecting the final product's aroma profile (Shin & Lee, 2019)

- **Sensory Evaluation of Regional Alcohols**

Sensory evaluation was conducted on attributes such as taste, smell, sourness, and overall acceptability. The highest mean score for overall acceptability was observed in samples from Kulekhani (KK), while Silgadi (SG) scored the lowest. This evaluation highlights the sensory appeal of different regional products, with panelists favoring the balanced profiles of Kulekhani's sample over other regions. Statistical analysis confirmed no significant differences in taste across the samples ($p > 0.05$), suggesting that regional preferences may largely influence sensory attributes

- **Sensory evaluation of alcohol prepared from different murcha samples**

Sensory evaluation of prepared alcohol samples using different murcha samples colleted from different locations was performed for taste, smell, sourness, and overall acceptability. Twelve semi-trained panelists from the National Food Research Centre participated in the sensory evaluation. Each panelist received coded samples as well as a sensory evaluation card. As a result, the hedonic scoring test for taste, smell, sourness, and overall acceptability was carried out as described by (Ranganna, 1986). The data were statistically by one-way analysis of variance (ANOVA) using a full factorial model (IBM SPSS Statistics for Windows, Version 26.0: IBM Corp, USA).

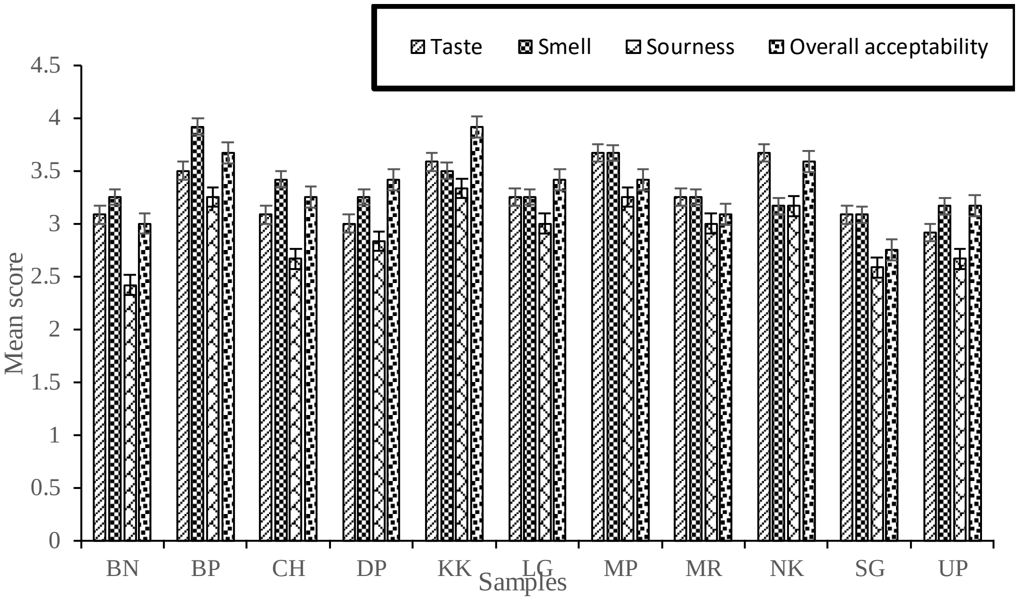

Figure 5. Bar diagram showing the mean score of different sensory attributes of alcohol samples

Where,

BN - Jand prepared using murcha from Birendranagar
BP - Jand prepared using murcha from Begnas Pokhara
CH - Jand prepared using murcha from murcha of Chitlang
DP - Jand prepared using murcha from Ghanpokhara
KK - Jand prepared using murcha from Kulekhani
LG - Jand prepared using murcha from Lamjung
MP - Jand prepared using murcha from Mandandeupur
MR - Jand prepared using murcha from Morang
NK - Jand prepared using murcha from Nuwakot
SG - Jand prepared using murcha from Silgadi
UP - Jand prepared using murcha from Udaypur

From the statistical analysis (ANOVA), the taste attribute of the alcohol samples shows a value of $p>0.05$, which means there is no significant difference between the samples and the taste of the panelists, suggesting homogeneity of the variances. Similarly, in the context of other sensory attributes i.e. taste, smell, sourness, and overall acceptability the value of p is greater than 0.05($p>0.05$), which means there are also no significant differences between the sensory attributes and the different alcohol samples. The highest mean score for overall acceptability was of sample KK

(3.92) and SG (2.75) had the lowest. The order of superiority based on the overall acceptability of different alcohol samples is as follows:

KK >BP >NK >DP >LG >MP >CH >UP >MR >BN >SG

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Special Project

1. Quality improvement of Asian Food Composition Database (AFCD+) Project

Executive Summary:

The AFCD+ project successfully established its operational framework in Year 1 (2081/82), constituting the National Database Steering Committee (NDSC), developing comprehensive guidelines, and selecting 16 ethnic foods and 100 ingredients for analysis. Preliminary nutritional analysis was initiated on a prioritized set of 4 ethnic foods and 48 ingredients. Building on this foundation, the research gap for Year 2 is the completion of robust nutritional profiling for the majority of selected foods and the expansion of data dissemination. The objective for this fiscal year is to analyze 8 ethnic foods and 50 ingredients, focusing on proximate composition, key minerals, and vitamins. The methodology will adhere to approved SOPs aligned with AOAC and FAO/INFOODS guidelines. Expected outputs include a significant expansion of the nutritional database, documentation of traditional knowledge, and enhanced laboratory capacity through progress towards ISO/IEC 17025:2017 accreditation. This will provide critical evidence for shaping national nutrition andand agricultural policies, valorizing indigenous food resources, and contributing to regional food composition efforts.

The study documents and standardizes Nepal's diverse ethnic foods, reflecting the culinary traditions of over 140 ethnic groups across seven provinces. The Nepal Food Research Centre (NFRC), under NARC, collaborated with local communities to collect authentic samples like Thakali Khana, Yomari, and Ghonghi,, ensuring cultural accuracy. Comprehensive proximate, mineral, vitamin, and beta-carotene analyses were conducted on both raw and cooked foods using AOAC methods. Key findings show significant nutrient changes due to cooking and nutrient retention factor: for example, protein and iron decreased in legumes like daal after preparation, while fermented foods like gundruk achar exhibited high calcium (308.76 mg/100g) and iron (12.20 mg/100g). Dairy-based khuwa was rich in calcium (550.19 mg/100g), while kodo flour and sinki showed high iron and calcium in raw forms. Ghonghi, a mollusk consumed by ethnic communities, was found rich in phosphorus (176 mg/100g) and protein. The research underscores the impact of processing on nutrition, supports preservation of indigenous knowledge, and aims to integrate traditional foods into mainstream markets through scientific validation and policy support.

1.1. Ethnic Foods and Cultural Diversity in Nepal

Nepal's ethnic foods are a mirror of its cultural and geographic diversity. With more than 140 ethnic groups spread across the mountains, hills, and Terai, every community has nurtured its own food traditions, influenced by local ingredients, farming practices, and lifestyles. Staples such as rice, maize, millet, lentils, and vegetables form the foundation of Nepalese cuisine, enriched with regional spices, herbs, and age-old cooking methods. These dishes go far beyond nutrition; they are a living expression of Nepal's identity, history, and heritage.

Selection and Documentation of Local Foods

To safeguard and celebrate this culinary heritage, the Nepal Food Research Centre (under NARC) undertook a study to document representative foods from all seven provinces. This work was carried out in close collaboration with local communities and authentic food establishments, ensuring that recipes and preparation methods were captured in their most genuine form. Both raw ingredients and cooked dishes were collected and analyzed for their nutritional and cultural value.

Community Engagement: Knowledge was gathered directly from local residents, expert chefs, and cultural custodians through interviews and discussions, supported by references from publications and reports. This approach helped preserve authentic voices often overlooked in formal research.

Survey of Representative Foods: In partnership with the Asian Food Composition Database (AFCD) Project, ten foods were selected to represent Nepal's provinces: Bhakka, Khapse, and Kinema (Koshi); Thekuwa (Madhesh); Yomari and Choila (Bagmati); Thakali Khana Set (Gandaki); Ghonghi (Lumbini); Dhindo (Karnali); and Kaguno Kheer (Sudurpaschim). Additionally, Dal Bhat Tarkari was recognized as the country's everyday staple.

Ensuring Authenticity: Ingredients and dishes were sourced directly from their traditional communities, for example, the Thakali Khana Set was obtained from the Thakali people, while Yomari and Choila came from Newar households in Kathmandu. This ensured that the samples reflected true cultural practices and not modified versions

The scope of this research includes the study of traditional processing techniques, with particular focus on fermentation practices applied in alcoholic beverages, kinema (fermented soybeans), and pickles. In addition, NFRC has examined culturally significant food items such as the rice and dhido Thakali sets, khapse, bhakka, thekuwa, kaguno ko kheer, choila, yomari, and ghongi.

The research framework covers both raw ingredients and cooked food products, assessing proximate composition, mineral and vitamin levels, and beta-carotene content. Findings demonstrate considerable variation in nutrient composition across samples, underscoring the impact of cooking methods, ingredient mixing, and other preparation factors on final nutritional values.

Through this initiative, NFRC aims to strengthen evidence-based policy formulation, ensure the scientific preservation of indigenous food knowledge, and support the integration of traditional Nepalese foods into broader food systems and markets

1.2. Thaklai rice and dhido sets

Thaklai rice and dhido sets were the samples collected from Lovely hill,Pokhara,Kaski as a representation of a traditional ethnic food in the ongoing ethnic food project.till now various analysis have been performed in both cooked and raw foods and ingredients collected from this place.

The proximate composition was determined according to the Official Methods of Analysis of the Association of Official Analytical Collaboration International (AOAC). Moisture content was determined using AOAC method no. 926.08 (AOAC,2023). Protein content was determined by the Kjeldahl method following AOAC method no. 920.87 (AOAC,2023). Fat content was determined using AOAC method no. 933.05 (AOAC,2023). Ash content was determined using AOAC method 923.03(AOAC,2023)

Table 49: Proximate and minerals analysis of rice and dhido thakali sets

Sample	Moisture %	Fat%	Protein%	Calcium (mg/100g)	Iron (mg/100g)	Beta carotene mg/100g	Vitamin C (mg/100g)
Jetho budo rice	14.98±0.152	0.9±0.426	7.73±0.534	7.74±3.854	1.02±0.236	-	-
Daal	10.74±0.082	0.75±0.167	20.74±0.247	31.28±6.794	4.73±0.677	-	-
Cabbage	91.88±0.099	0.11±0.002	1.38±0.017	23.68±11.248	1.33±0.616	0.09	-
Potato	82.26±0.461	0.03±0.001	1.39±0.656	29.74±2.732	5.1±0.075	0.07	-
Local chicken	80.79±0.133	5.34±0.056	14.75±6.957	57.4±27.431	0.89±0.083	-	-
Cauliflower	89.81±0.125	0.46±0.009	1.79±0.155	52.43±24.728	2.21±1.072	0.03	-
Khole saag	92.91±0.282	0.3±0.143	2.28±0.081	7.13±3.374	4±1.632	4.73	-
Cucumber	95.57±0.024	0.12±0.031	0.91±0.399	10.04±4.741	0.9±0.452	0.81	1.03
Carrot	89.57±0.272	0.22±0.011	0.57±0.009	22.38±1.491	0.67±0.023	10.57	4.27
Tomato	94.41±0.278	0.24±0.008	0.9±0.008	5.1±0.63	0.262±0.038	1.86	21.74
Paneer	54.45±0.246	23.97±11.3	29.99±14.16	429.85±202.7	1.145±0.128	-	-

Values with different letters in the superscripts differ significantly($p< 0.05$)
Values presented are means ± SD of triplicate values.

Table 50: Proximate and minerals analysis of rice and dhido thakali sets

Sample	Moisture %	Fat%	Protein%	Iron(mg/100 g)	Calcium(mg/100 g)
Jetho	62.041±0.3	0.1±0.006	2.87±1.356	0.814±0.098	5.074±2.404
Daal	65.508±0.0	2.48±1.168	9.95±4.69	3.104±1.499	37.933±18.073
Cauli	82.545±0.6	4.22±0.058	2.18±0.137	3.443±1.713	13.06±6.381
Potato	72.186±0.6	1.55±0.73	4.1±1.931	1.334±0.122	19.262±5.353
Paneer	62.746±0.0	15.66±0.03	13.85±6.54	1.087±0.051	132.729±3.103
Paneer	53.583±0.2	25.21±11.8	9.71±4.576	0.324±0.333	397.335±16.732
Mixed	78.168±1.0	5.99±0.031	4.37±0.11	1.301±0.614	39.933±18.829
Cabbage	90.618±0.1	0.52±0.245	0.99±0.467	0.275±0.027	44.633±5.518
Cucumbe	92.542±0.1	1.45±0.686	0.98±0.073	0.383±0.054	25.551±2.791
Carrot	85.372±1.6	1.6±0.753	1.75±0.827	0.438±0.077	34.941±6.772
Local	71.94±0.48	6.86±0.124	16.11±1.33	11.162±5.319	98.367±52.044
Tomato	87.901±0.0	2.27±0.069	2.39±0.097	0.943±0.446	76.146±35.895
Khole	78.77±0.80	12.4±0.112	7.19±4.157	2.488±1.174	90.199±52.118
Kodo	32.171±0.0	0.45±0.046	4.71±2.226	6.514±0.467	108.632±2.411

1.3. Raw Foods

In the cereal group, Jetho budo rice was the only sample, containing about 14.98% moisture, 0.9% fat, 7.73% protein, 7.74 mg calcium, and 1.02 mg iron per 100 g. In general, cereals typically contain about 8–14% moisture, 6–12% protein, 0.5–3% fat, 5–40 mg calcium, and 1–5 mg iron per 100 g, depending on species and milling or processing (FAO/INFOODS; USDA FoodData Central).

The legume group, represented by daal, had 10.74% moisture, 0.75% fat, 20.74% protein, 31.28 mg calcium, and 4.73 mg iron per 100 g. Across legumes more broadly, dry seeds commonly fall around 8–13% moisture, 18–26% protein, and 1–6% fat, with minerals often spanning roughly 20–150 mg calcium and 3–10 mg iron per 100 g; variability reflects species (e.g., lentil, chickpea, pea, common bean) and cultivar as well as pre-treatments such as soaking or cooking (Iqbal et al., 2006; Costa et al., 2006; El Tinay et al., 1989; Sebastiá et al., 2001).

The vegetables included cabbage, potato, cauliflower, khole saag, cucumber, carrot, and tomato. Their nutritional values ranged widely, with moisture between 82.26 and 95.57%, fat from 0.03 to 0.46%, and protein from 0.57 to 2.28%. Calcium levels varied between 5.1 and 52.43 mg, while iron ranged from 0.262 to 5.1 mg per 100 g. Vegetables also contributed carotenoids and vitamin C, with beta-carotene ranging from 0.03 to 10.57 mg and vitamin C from 0.07 to 21.74 mg per 100 g. Generally, vegetables (leafy and non-leafy) present high moisture (≈80–96%) with relatively low macronutrients by weight (≈0.5–4% protein and ≈0.1–1% fat), while mineral contents vary by species and preparation; for example, leafy greens such as spinach show broad mineral ranges across cultivars and cooking methods, and boiling can markedly change soluble constituents (James et al., 2020; Chai & Liebman, 2005).

The animal products, represented by local chicken and paneer, showed lower moisture compared to vegetables, ranging from 54.45 to 80.79%, but much higher fat and protein contents, with fat between 5.34 and 23.97% and protein between 14.75 and 29.99%. Calcium was also markedly higher in this group, ranging from 57.4 to 429.85 mg, while iron content varied only slightly between 0.89 and 1.145 mg per 100 g. More broadly, typical proximate ranges for common animal-source foods such as poultry and dairy fall around 60–75% moisture, 15–30% protein, and 5–25% fat, with minerals varying by cut and product type (e.g., calcium substantially higher in dairy; iron comparatively modest in poultry muscle) (Ogunmola et al., 2013; Demirbaş, 1999).

1.4. Prepared, mixed and cooked foods

In the cereal or traditional food group, which included Jetho budo rice and kodo dhido, the values in moisture are ranging from 32.17 to 62.04%. Fat was minimal, between 0.10 and 0.45%, while protein ranged from 2.87 to 4.71%. Iron varied from 0.814 to 6.514 mg, and calcium ranged from 5.07 to 108.63 mg per 100 g. As a reference point, cereals in general tend to fall near 8–14% moisture (raw, unprepared), 6–12% protein, and 0.5–3% fat, with roughly 5–40 mg calcium and 1–5 mg iron per 100 g; cooking, dilution with water, and addition of other ingredients shift these values within mixed dishes (FAO/INFOODS; USDA FoodData Central).

The legume group, represented solely by daal, showed a moisture content of 65.51%, fat at 2.48%, protein at 9.95%, iron at 3.10 mg, and calcium at 37.93 mg per 100 g. In broader terms, legumes typically show about 8–13% moisture in the dry state, 18–26% protein, and 1–6% fat, with calcium commonly around 20–150 mg and iron near 3–10 mg per 100 g; household processing (soaking, boiling, or pressure-cooking) alters mineral levels and dialysability to varying degrees across species (Iqbal et al., 2006; Costa et al., 2006; El Tinay et al., 1989; Sebastiá et al., 2001).

Among vegetables and mixed vegetable dishes such as cauli aalu tarkari, potato, mixed achar, cabbage, cucumber, carrot, tomato achar, and khole saag, moisture was consistently high, ranging from 72.19 to 92.54%. Fat content showed more variation, between 0.52 and 12.40%, while protein levels spanned from 0.98 to 7.19%. Iron ranged from 0.275 to 3.44 mg, and calcium varied widely from 13.06 to 90.20 mg per 100 g. In general, vegetables present ≈80–96% moisture with protein ≈0.5–4% and fat ≈0.1–1% on a raw weight basis, though recipes and cooking methods can concentrate or leach components; boiling, for instance, has been shown to substantially reduce soluble oxalate in several vegetables (James et al., 2020; Chai & Liebman, 2005).

The animal product group, consisting of paneer aalu tarkari, paneer, and local chicken gravy, had moisture between 53.58 and 71.94%. This group was richer in fat, ranging from 6.86 to 25.21%, and protein, which spanned from 9.71 to 16.11%. Iron content ranged more widely, between 0.324 and 11.16 mg per 100 g, while calcium was highest in this group, varying from 98.37 to 397.34 mg per 100 g. Overall, common ranges for animal-source foods such as poultry and dairy products are around 60–75% moisture, 15–30% protein, and 5–25% fat, with higher calcium typical of dairy matrices and relatively modest iron in poultry muscle (Ogunmola et al., 2013; Demirbaş, 1999)

1.5. Ethnic food Ghandruk

Ghandruk raw

Table 51: Proximate and Mineral analysis of raw samples from Ghandruk

Sample	Moisture (%)	Fat (%)	Protein (%)	Iron (mg/100g)	Calcium (mg/100g)	Vit C (mg/100g)	Beta carotene (mg/100g)
Tomare Rice	10.60±0.82	0.74±0.03	6.15±4.46	2.13±1.70	21.69±22.32		
Daal (Musuro+ Kalo)	11.92±0.11	2.46±2.78	14.75±4.36	3.79±0.31	28.88±3.39		
Sinki	12.67±0.33	0.43±0.09	5.97±2.09	9.46±8.21	99.00±85.74	9.48	
Potato	76.52±0.86	0.04±0.005	1.81±8.65	2.41±2.09	5.10±4.43	19.68	0.07
Chicken meat	72.49±1.31	11.93±0.63	19.03±8.23	1.65±1.43	35.17±30.48		
Raayo saag	93.28±0.25	0.19±0.01	2.65±1.92	2.93±0.57	19.02±16.48	37.95	5.2
Kodo Flour	10.16±0.82	1.36±0.02	6.43±6.02	8.80±7.63	100.06±86.73		
Gundruk	12.76±0.29	0.92±0.831.1	17.61±0.82			34.54	

- **Moisture content**

Moisture content of tomare rice (Cereal), daal (musuro and kalo) (Legume) and dried fermented food like gundruk were 10.60%, 11.92% and 12.76% respectively. They were the lowest among the samples collected from Ghandruk. Potato, raayo saag and sinki from vegetable group had 76.52% , 93.28% and 12.67% moisture content respectively. Chicken meat had moisture content 72.49%.

- **Fat content**

It was observed that fat content was low among all the samples with chicken meat showing the highest fat content (11.93±0.63) among all. Daal (2.46±2.78)had the second highest fat content. The lowest fat content was observed in vegetables:potato (0.04±0.005), raayo saag(0.19±0.01) and sinki (0.43±0.09), followed by fermented vegetable gundruk(0.92±0.83), and cereals: tomare rice(0.74±0.03) and kodo flour (1.36±0.02).

- **Protein content**

Among the raw foods, the protein content of chicken (19.03±8.23) , gundruk (17.61±0.82) and daal (14.75±4.36) were the highest. Tomare rice , sinki, potato, raayo saag and kodo flour had lower protein content (6.15±4.46, 5.97±2.09, 1.81±8.65, 2.65±1.92 and 6.43±6.02 respectively).

- **Iron**

Sinki (9.46±8.21 mg/100g) had the highest iron content among all the raw samples followed by kodo flour (8.80±7.63 mg/100g). Chicken meat had the lowest iron content (1.65±1.43 mg/100g).

- **Calcium**

Kodo flour (100.06±86.73 mg/100g) had the highest calcium content, followed by sinki (99.00±85.74 mg/100g). Chicken meat, daal and tomare rice had 35.17±30.48 mg/100g, 28.88±3.39 mg/100g and 21.69±22.32 mg/100g respectively. Raayo saag (19.02±16.48 mg/100g) and potato (5.10±4.43 mg/100g) had the lowest calcium content.

- **Vitamin C and Beta carotene**

Vit C were analyzed of only vegetables and Beta carotene was analyzed of only fresh vegetables. Vit C content of sinki, potato, raayo saag and gundruk were 9.48 mg/100g, 19.68mg/100g, 37.95mg/100g and 34.54mg/100g respectively.

Beta carotene content of potato and raayo saag were 0.007 mg/100g and 5.2 mg/100g respectively.

Ghandruk cooked

Table 52: Proximate and Mineral analysis of cooked samples from Ghandruk

Sample	Moisture (%)	Fat (%)	Protein (%)	Iron (mg/100g)	Calcium (mg/100g)	Vit C (mg/100g)
Tomare Rice	57.59±0.26	0.11±0.02	2.95±0.53	2.21±1.92	5.83±8.78	
Daal (Musuro+Kalo)	84.32±1.66	1.07±0.06	2.22±1.92	1.03±0.89	5.08±4.54	
Sinki aalu tarkari	21.18±0.46	13.33±11.54	8.85±0.69	6.45±2.61	66.93±46.16	3.2
Chicken gravy	73.78±0.63	9.65±0.15	16.42±1.28	1.10±0.16	175.87±152.92	
Raayo saag	78.82±0.19	7.32±0.11	3.17±0.04	2.40±0.16	12.50±8.14	24.56
Kodo ko Dhido	63.61±1.15	0.27±0.02	3.61±0.32	2.74±0.33	73.65±8.95	
Gundruk achar	21.24±1.53	25.27±0.59	21.46±0.43	12.20±1.39	308.76±28.89	20.17

- **Moisture content**

Almost everything cooked showed much higher moisture because of water addition during cooking — rice (57.59%), daal (84.32%), chicken gravy (73.78%). Sinki aalu tarkari (21.18%) and gundruk achar (21.2%) moisture content remained relatively low.

- **Fat content**

Fat content increased in cooked foods, sinki aalu tarkari (13.33±11.54), raayo saag (7.32±0.11) and gundruk achar (25.27±0.59) in comparison of their raw counterparts. Chicken gravy had fat content of 9.65±0.15, while tomare rice (0.11±0.02) and kodo ko dhido (0.27±0.02) had low fat contents.

- **Protein**

Protein content dropped in cooked dishes with chicken gravy (6.42±1.28) had the highest among all. Gundruk achar (21.46±0.43) had the second highest protein content. The other protein content for Tomare rice , daal, sinki aalu tarkari, raayo saag and kodo ko dhido were 2.95±0.53, 2.22±1.92, 8.85±0.69, 3.17±0.04 and 3.61±0.32 respectively.

- **Iron**

Gundruk achar (12.20±1.39 mg/100g) had the highest iron content followed by sinki aalu tarkari(6.45±2.61mg/100g). The lowest iron content was in chicken gravy(1.03±0.89 mg/100g).

- **Calcium**

Gundruk achar (308.76±28.89mg/100g) had the highest calcium content followed by chicken gravy(175.87±152.92mg/100g). Daal(5.08±4.54mg/100g) shad the lowest calcium content.

- **Vitamin C**

Vitamin C content of raayo saag (24.56 mg/100g) was the highest. Gundruk achar had vit C content of 20.17 mg/100g and sinki aalu tarkari had vit C content of 3.2 mg/100g.

1.6. Yomari, Bhakka, Kaguno Kheer, Kapse

Raw ingredients and cooked ethnic food samples (Yomari, Bhakka, Kaguno kheer, Khapse) were collected from Kathmandu and Rasuwa. The samples were subjected to analyze for its proximate, mineral analysis.

Table 53: Proximate and mineral analysis of Raw Ingredients

Sample	Moisture (%)	Fat (%wb)	Protein (%wb)	Iron (mg/100g) (wb)	Calcium (mg/100g) (wb)
Taichin Rice Flour	12.38±0.19	0.62±0.06	7.37±0.27	7.50	17.88
Khuwa	31.37±3.22	26.21±1.73	21.24±1.41	3.22	550.19
Kaguno	11.64±0.47	3.64±1.72	10.88±0.27	6.92	17.16
Mixed Dry Fruits	10.27±0.16	23.65±3.31	15.08±0.52	8.19	28.56
Maida	12.42±0.15	0.90±0.42	10.56±0.17	6.99	12.98

- **Moisture content**

Khuwa exhibited the highest moisture level (31.37±3.22%), reflecting its semi-solid dairy nature. (Aggarwal et al., 2019) reported that moisture content in khuwa prepared from buffalo milk was 21.76% and khuwa prepared from lactose hydrolyzed milk was 22.13%. Mixed Dry Fruits had the lowest moisture (10.27±0.16%), aligning with their dehydrated and concentrated form. Taichin Rice Flour (12.38±0.19%), Kaguno (11.64±0.47%), and Maida (12.42±0.15%) showed similar moderate moisture levels typical of flours and cereals. (Kumar et al., 2008) reported 11.7% moisture content in raw rice. (Suwarna et al., 2019) reported that 10.8% moisture content in kaguno (foxtail millet).

- **Fat content**

Khuwa was extremely rich in fat (26.21±1.73%), due to its milk-solid concentration. Mixed Dry Fruits also contained high fat (23.65±3.31%), typical of nut and seed components. Kaguno had moderate fat (3.64±1.72%), higher than rice flour (0.62±0.06%) and Maida (0.90±0.42%). (Suwarna et al., 2019) reported 4.5% fat content in kaguno (foxtail millet).

- **Protein content**

Khuwa was the richest in protein (21.24±1.41%), consistent with its dairy origin. Mixed Dry Fruits (15.08±0.52%) and Kaguno (10.88±0.27%) also provided good protein levels. Maida (10.56±0.17%) and Taichin Rice Flour (7.37±0.27%) had comparatively lower protein contents. (Suwarna et al., 2019) reported 11.2% protein content in kaguno (foxtail millet).

- **Iron Content**

Mixed Dry Fruits contained the highest iron (8.19 mg/100g). Taichin Rice Flour (7.50 mg/100g) and Maida (6.99 mg/100g) also provided considerable amounts. Kaguno had slightly lower iron (6.92 mg/100g). Khuwa was the least iron-rich (3.22 mg/100g).

- **Calcium content**

Khuwa was exceptionally rich in calcium (550.19 mg/100g), consistent with milk-based products. Other foods provided much lower calcium: Mixed Dry Fruits (28.56 mg/100g) > Taichin Rice Flour (17.88 mg/100g) > Kaguno (17.16 mg/100g) > Maida (12.98 mg/100g).

Table 54: proximate and mineral analysis of cooked ethnic foods

sample	Moisture (%)	Fat (% wb)	Protein (%wb)	Iron (mg/100g) (wb)	Calcium (mg/100g) (wb)
Yomari	48.27±0.37	4.92±0.02	5.18±0.19	4.44	13.46
Bhakka	42.76±1.12	0.24±0.01	5.67±0.13	5.59	17.87
Tomato	89.18±0.21	5.46	2.15	0.866	4.12
Kaguno	82.57±0.41	2.35±0.08	2.56±0.21	0.91	31.09
Khapse	5.65±0.08	20.16±1.85	11.43±0.14	1.94	21.56

- **Moisture content**

Moisture levels varied widely among the samples. Tomato Achar (89.18%) recorded the highest moisture, followed by Kaguno Kheer (82.57%), making both highly perishable and less suitable for long storage. Yomari (48.27%) and Bhakka (42.76%) also contained high moisture, typical of steamed cereal-based products, which contributes to their soft texture but short shelf-life. In contrast, Khapse (5.65%) had extremely low moisture, making it the driest and most shelf-stable food among all samples.

- **Fat content**

Fat levels showed clear differences across foods. Khapse (20.16%) contained the highest fat due to its deep-fried preparation, making it an energy-dense snack. Tomato Achar (5.46%) and Yomari (4.92%) provided moderate fat contributions, while Kaguno Kheer (2.35%) was relatively low in fat. Bhakka (0.24%), a steamed rice-based dish, contained negligible fat, classifying it as a very lean food.

- **Protein content**

Protein content was highest in Khapse (11.43%), positioning it as the best protein source among the studied foods. Bhakka (5.67%) and Yomari (5.18%) contributed modest amounts, sufficient to provide some nutritional value but not as rich as dairy or legumes. Kaguno Kheer (2.56%) and Tomato Achar (2.15%) showed the lowest protein levels, indicating that these foods are not strong protein providers.

- **Iron content**

Iron levels varied considerably. Bhakka (5.59 mg/100g) was the richest iron source, followed closely by Yomari (4.44 mg/100g). Khapse (1.94 mg/100g) contributed moderate iron, while Kaguno Kheer (0.91 mg/100g) and Tomato Achar (0.87 mg/100g) were poor iron sources. This suggests that cereal-based steamed items like Bhakka and Yomari can help in addressing iron needs better than fried or dairy-based alternatives.

- **Calcium content**

Calcium levels were highest in Kaguno Kheer (31.09 mg/100g), indicating its strength as a mineral-rich food. Khapse (21.56 mg/100g) and Bhakka (17.87 mg/100g**)** also contributed meaningful amounts of calcium, while Yomari (13.46 mg/100g) contained a lower level. Tomato Achar (4.12 mg/100g) was the poorest calcium source among the tested samples.

1.7. Ethnic Foods and Cultural Diversity in Nepal

The term ethnic food refers to the traditional cooking of a specific ethnic group, culture, or nation; it is frequently distinguished by the use of regional ingredients and customs. Nepal's ethnic foods are a mirror of its cultural and geographic diversity. With more than 140 ethnic groups spread across the mountains, hills, and Terai, every community has developed its own unique food traditions, shaped by local ingredients, farming practices, and lifestyles. Staples such as rice, maize, millet, lentils, and vegetables form the foundation of Nepalese cuisine, enriched with regional spices, herbs, and age-old cooking methods. These dishes go far beyond nutrition they are a living expression of Nepal's identity, history, and heritage.

Proximate composition of cooked samples

The ingredients of the thakali khana and dhido set cooked samples obtained from Fewa Lake, Pokhara, were subjected to proximate analysis. The result is shown in the table below:

Table 55: Composition of Raw Ethnic Food Samples.

Sample	Moisture (%)	Fat (%)	Protein (%)	Vit C (mg/100 g)	B-Carotene (mg/100 g)
Mangalam Rice	11.34±0.058	0.58±0.25	8.78±0.08		
Simi Dahl	10.92±0.194	1.27±0.125	20.07±0.30		
Rayo Saag	92.86±0.104	0.21±0.005	2.63±0.05	21.71	4.3
Aalu	75.39±1.022	0.03±0.002	3.78±0.12	24.64	0.07
Mutton	58.62±0.490	14.7±0.36	39.1±0.73		
Fish	22.46±1.316	13.58±0.11	66.88±0.92		
Dhido	12.23±0.143	2.13±0.031	11.37±0.07		
Cucumber	95.18±0.476	0.11±0.005	0.91±0.01	1.83	0.81
Mula	89.52±1.670	0.12±0.013	0.62±0.01		0.43
Mushroom	90.35±0.388	0.15±0.006	1.75±0.04		
Gundruk	12.76±0.239	1.39±0.21	17.86±0.22		
Tomato	95.15±0.416	0.06±0.003	0.62±0.02	28.61	1.86
Carrot	87.93±0.517	0.15±0.004	0.48±0.01	3.71	10.57
Cauli	91.12±0.167	0.14±0.005	1.7±0.09	41.63	0.03
Onion	86.23±0.315	0.1±0.029	1.88±0.01		

Table 56: Proximate composition of Cooked Ethnic Food Samples

Sample	Moisture (%)	Fat (%)	Protein (%)
Mangalam Rice	64.93±50	0.09±0.01	3.36±0.04
Simi Dahl	73.67±0.65	9.26±0.15	5.17±0.17
Rayo Saag	72.09±0.50	19.46±0.01	8.6±0.36
Aalu Tareko	63.19±0.69	3.78±0.14	3.15±0.03
Mutton Curry	71.7±0.18	10.21±0.08	15.92±0.12
Fish Curry	79.67±0.18	4.31±0.12	10.8±0.31
Dhido	74.43±0.10	0.36±0.05	3.58±0.02
Cucumber Achar			
Mula Achar	86.12±0.66	6.28±0.16	2.45±0.06
Mushroom Curry	78.99±1.24	6.28±0.24	3.3±0.02
Gundruk Achar	30.89±0.68	9.72±0.10	
Tomato Achar	86.74±0.04	0.49±0.03	1.5±0.01

- **Moisture**

The moisture content of ethnic food samples (both raw and cooked) was analyzed. For cereals, the moisture content ranged from 11.34±0.058% to 12.23±0.143% in raw samples, increasing significantly to 64.93±50% to 74.43±0.10% in cooked samples. In legume samples, moisture content showed a substantial rise from 10.92±0.194% (raw) to 73.67±0.65% (cooked). Vegetables displayed a broad moisture range, from 12.76% to 95.18% in raw form, which shifted to 30.89% to 86.74% after cooking. Meat samples exhibited moisture content values between 22.46% and 58.62% when raw, which increased further to a range of 71.7% to 79.67% after cooking.

- **Fat**

The fat content of ethnic food samples (raw and cooked) was analyzed. For cereals, fat content ranged from 0.58±0.25% (Mangalam Rice) to 2.13±0.031% (Dhido) in raw samples and decreased to 0.09±0.01% (Mangalam Rice) to 0.36±0.05% (Dhido) in cooked samples. In legume samples, fat content ranged from 1.27±0.125% (Simi Dahl) in raw form to 9.26±0.15% (Simi Dahl) in cooked form. For meat samples, fat content ranged from 13.58±0.11% (Fish) to 14.7±0.36% (Mutton) in raw samples and from 4.31±0.12% (Fish Curry) to 10.21±0.08% (Mutton Curry) in cooked samples.

- **Protein**

The protein content of ethnic food samples varied between raw and cooked states as well. Cereals had protein content ranging from 8.78±0.08% (Mangalam Rice) to 11.37±0.07% (Dhido) in raw samples and decreased to 3.36±0.04% (Mangalam Rice) to 3.58±0.02% (Dhido) after cooking. Legumes showed protein content from 20.07±0.30% (Simi Dahl) in raw form to 5.17±0.17% (Simi Dahl) in cooked form. Meat samples exhibited protein content ranging from 39.1±0.73% (Mutton) to 66.88±0.92% (Fish) in raw form and 10.8±0.31% (Fish Curry) to 15.92±0.12% (Mutton Curry) in cooked form.

Mineral content

Raw and cooked samples were subjected to ultimate analysis. The results obtained are listed in the table below.

Table 57: Mineral Content of Cooked Ethnic Food Samples

Sample	Iron (mg/100g)	Calcium (mg/100g)
Mangalam Rice	0.37±0.067	8.75±4.42
Simi Dahl	1.92±0.37	67.36±5.66
Rayo Saag	4.34±3.59	141.67±17.57
Aalu Tareko	1.33±0.12	14.35±1.85
Mutton Curry	1.32±0.12	58.37±32.08
Fish Curry	-	33.58±1.92
Dhido	2.21±0.30	13.94±0.11
Cucumber Achar	-	-
Mula Achar	1.38±0.24	55.05±2.05
Mushroom Curry	-	14.76±1.42
Gundruk Achar	7.88±0.58	547.895±80.92
Tomato Achar	0.28±0.05	24.12±2.42

Table 58: Mineral content of Raw Ethnic Food Samples

Sample	Iron (mg/100g)	Calcium (mg/100g)
Mangalam Rice	2.1±0.08	8.07±4.02
Simi Dahl	27.37±1.60	57.81±3.94
Rayo Saag	0.5±0.06	26.38±1.65
Aalu	1.5±0.51	8.01±0.33
Mutton	1.79±0.13	15.9±3.49
Fish	2.31±0.43	856.07±56.16
Dhido	4.54±0.14	9.52±5.04
Cucumber	0.28	19.15±1.61
Mula	0.53±0.10	35.83±3.49
Mushroom	1.26±0.13	1.96±0.74
Gundruk	13.97±1.60	1078.42±16.20
Tomato	0.22±0.03	4.42±0.55
Carrot	0.67±0.03	21.66±1.73
Cauli	1.92±0.93	45.66±0.76
Onion	0.24±0.15	6.45±2.39

- **Iron**

The iron content of ethnic food samples (raw and cooked) was analyzed. For cereals, iron content ranged from 0.37±0.067 mg/100g (Mangalam Rice, cooked) to 4.54±0.14 mg/100g (Dhido, raw), with Mangalam Rice showing 2.1±0.08 mg/100g in raw samples. In legume samples, iron content ranged from 1.92±0.37 mg/100g

(Simi Dahl, cooked) to 27.37±1.60 mg/100g (Simi Dahl, raw). For meat samples, iron content ranged from 1.32±0.12 mg/100g (Mutton Curry, cooked) to 1.79±0.13 mg/100g (Mutton, raw).

Dhido had the highest iron content among cereals at 4.54±0.14 mg/100g (raw), and Mangalam Rice had the lowest at 0.37±0.067 mg/100g (cooked). Gundruk Achar had the highest iron content among cooked samples overall at 7.88±0.58 mg/100g, while Tomato Achar had the lowest at 0.28±0.05 mg/100g. In raw samples, Simi Dahl had the highest iron content at 27.37±1.60 mg/100g, and Tomato had the lowest at 0.22±0.03 mg/100g.

- **Calcium**

The calcium content of these samples showed variation as well. For cereals, calcium ranged from 8.07±4.02 mg/100g to 8.75±4.42 mg/100g (Mangalam Rice, raw and cooked) and up to 13.94±0.11 mg/100g in Dhido (cooked). Legumes had calcium content ranging from 57.81±3.94 mg/100g (Simi Dahl, raw) to 67.36±5.66 mg/100g (Simi Dahl, cooked). In meat samples, calcium content ranged from 15.9±3.49 mg/100g (Mutton, raw) to 58.37±32.08 mg/100g (Mutton Curry, cooked). Vegetables showed a wide range with iron content from 0.5±0.06 mg/100g (Rayo Saag, raw) to 7.88±0.58 mg/100g (Gundruk Achar, cooked) and calcium content ranging from 4.42±0.55 mg/100g (Tomato, raw) to 547.895±80.92 mg/100g (Gundruk Achar, cooked).

Gundruk had the highest calcium content in raw samples at 1078.42±16.20 mg/100g, and Mangalam Rice had the lowest at around 8 mg/100g in both raw and cooked forms. Among cooked samples, Gundruk Achar stood out with the highest calcium content at 547.895±80.92 mg/100g, and Mangalam Rice had one of the lowest.

- **Cereals**

Cereals generally have a moisture content of about 8–14%, protein levels between 6–12%, fat ranging from 0.5–3%, along with calcium amounts of 5–40 mg and iron content of 1–5 mg per 100 grams, varying by type and how they are processed (FAO/INFOODS; USDA FoodData Central). For legumes, dry seeds typically contain around 8–13% moisture, 18–26% protein, and 1–6% fat, with mineral content typically ranging from 20–150 mg of calcium and 3–10 mg of iron per 100 grams. This variability is influenced by the type of legume (such as lentils, chickpeas, peas, or common beans), the specific cultivar, and pre-treatment processes like soaking or cooking (Iqbal et al., 2006; Costa et al., 2006; El Tinay et al., 1989; Sebastiá et al., 2001).

- **Vegetables**

Vegetables, whether leafy or non-leafy, usually have a high moisture content of approximately 80–96% and lower levels of macronutrients by weight, with about 0.5–

4% protein and 0.1–1% fat. Their mineral content varies widely depending on the species and preparation method. For instance, spinach, a leafy green, can show diverse mineral levels based on cultivar and cooking techniques, as boiling can significantly alter soluble components (James et al., 2020; Chai & Liebman, 2005).

- **Meat and Poultry**

Animal-source foods like poultry and dairy typically have moisture contents of around 60–75%, protein ranges of 15–30%, and fat content between 5–25%, with mineral levels differing based on the cut and product type—dairy generally has a much higher calcium level, while poultry muscle tends to have relatively low iron (Ogunmola et al., 2013; Demirbaş, 1999). In cooking, vegetables have about 80–96% moisture, 0.5–4% protein, and 0.1–1% fat when raw, but cooking methods can either concentrate or leach their components; for example, boiling is known to significantly reduce soluble oxalate levels in various vegetables (James et al., 2020; Chai & Liebman, 2005).

1.8. Analysis of ghongi, ethnic food of nepal.

Mollusks having the highest protein value are very popular among some ethnic groupslike Mushar, Dhangar, Malah, Paswan, Dhanuwar and Tharu. Some mollusk species have nutritional value as the meat of Ghonghi (Bellamya bengalensis) is high in protein which is considered as cheapest source of animal protein. The samples of Cooked and Uncooked Ghongi were collected from Hatiya Bazar of Beltar, Udayapur District. It is considered a source of income to some ethnic groups. As per the local shop, Ghongi were boiled and cooked with different spices for a spicy flavor and also, the soup can be consumed.

Table 59: Analysis of ghongi

Sample	Moisture%	Fat%	Ash%	Phosphorus
Uncooked ghongi	75.34 ± 0.75^{a}	5.83 ± 0.15^{a}	2.85 ± 0.07^{a}	165.23 ± 8.82^{a}
Cooked ghongi	62.21 ± 0.30^{a}	1.77 ± 0.08^{a}	4.06 ± 0.64^{a}	176 ± 0.83^{a}

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5. CONCLUSION

The fiscal year 2081/82 represents a period of measured progress for the National Food Research Centre, characterized by substantive scientific contributions alongside persistent institutional constraints. The Centre's research portfolio demonstrated particular strength in addressing Nepal's dual challenges of nutritional security and agricultural commercialization. The documentation of dramatic nutrient losses during rice polishing, coupled with the identification of iron-rich traditional varieties, provides actionable evidence for policy interventions in food processing standards. Similarly, the successful development of value-added products from mushrooms, soybeans, and ethnic foods offers pathways for rural economic development while preserving cultural heritage.

However, the Centre's impact remains constrained by structural limitations. The 45% vacancy rate in scientific positions limits research scope, while equipment procurement delays indicate systemic administrative challenges. The gap between the Centre's expanded mandate and its operational capacity suggests the need for strategic reassessment of priorities or enhanced resource allocation.

Looking forward, three strategic imperatives emerge: First, the translation of research findings into policy recommendations requires strengthened engagement with regulatory bodies and industry stakeholders. Second, the scaling of successful technologies, particularly in cardamom processing and fermented foods, demands partnership models that bridge research and commercialization. Third, the Centre's analytical services, while generating modest revenue, could be expanded to support quality assurance across Nepal's growing food processing sector. The Centre stands at a critical juncture where its technical competencies have matured, but institutional frameworks require modernization to fully realize its potential contribution to Nepal's food system transformation.

Annex 1: List of Laboratory Facilities 2081/82 (2024/25)

SN	Name of laboratory	Major instruments	Testing facilities
1	Analytical Lab	Autoclave, Microscope, Incubator	Sterilizing media, utensils used in a microbiology lab, total plate/viable count, salmonella, staphylococcus, E. coli, yeast, and mold.
		Spectrophotometer, Fermenter (Bioreactor with complete set-autoclave, cooler), Colorimeter, Flouri-meter, Lab Scale Centrifuge, Abbe Refractometer, Digital probe thermometer	Micro-nutrients such as amylase, curcumin, iron, phosphorus, calcium, tryptophan, lysine, vitamin C, amylase activity, Refractive index, and Processing temperature.
		Lab Scale- Wheat Mill, Rice Mill (Satake and Otake), Rice Polisher (Yamamoto), Dough Mixer, Lab Scale Baking Oven, Sample Divider, 2 digits digital balance.	Sampling, extraction rate, rice shelling, and polishing, dough testing, 1000-kernel weight, bulk density, L/B ratio.
		Hot Air Oven, Muffle Furnace, Protein analyzer (automatic Gerhard digestion and distillation set), crude fibre set, Water bath, 4 digits digital balance, V.D.R.L Rotator, Karl Fischer Titrator, Gerber Centrifuge, Cream Separator, Butter Churner, Cheese Presser, Micro Oven, Lactose (milk analyzer)	Moisture, total ash, crude protein, crude fibre, crude fat, peroxide value, carbohydrate, reducing and total sugar, food additives, hot water extract of tea and coffee, essential oils and oleoresin in spices, distilled water production.
		Crude fibre apparatus 6 sample, Microprocessor-based	Crude fibre analysis
		Dietary fibre apparatus 6 sample	Dietary fibre analysis
		Solar tunnel dryer	Drying
		Laminar flow cabinet	Microbiological study
		High-Performance Liquid Chromatography (HPLC) with complete accessories	Food analysis
		Gas Chromatography with Mass Spectroscopy (GCMS) with complete accessories	Food analysis
		Atomic SpectroPhotometer (AAS) with complete accessories	Mineral analysis
		Food Texture Analyzer Taxt. Plus	Texture profile analysis
		Food/Feed Analyzer Nirmaser Package	Food analysis
		Refractometer	Refractive index
		Polarimeter	Food analysis
		Lab purifier	
		Fat analyzer	Ether extract
		UV-vis Spectrometer	Food analysis
		Bomb Calorimeter	Food analysis
		Dual Syringe Diluter	Sample and reagent dilution

SN	Name of laboratory	Major instruments	Testing facilities
		Microwave Digester Multiwave	Food analysis
		Clevenger Apparatus	Essential oil Determination
		Orbital shaking incubator, Biobase Shaker	Shaker
		Water purification system	HPLC grade water
		Digital ultrasonicater	Sonicate
		Gel Electrophoresis imaging and analysis system	Protein analysis
		Laboratory Freezer (-80 degree centigrade)	Sample Storage
		Kjeldahl protein analyzer System	Protein Analysis
		Dietary Fibre analyzer	Dietary Fibre Analysis
		Micro Plate Reader	Bioactive components analysis
		Freeze Dryer	Drying
		Fume Hood	Chemical Storage
2	Technology Incubation Unit	Deep fridge	Freezing of Food commodities
		Refrigerator	Preservation
		Rice Polisher (Pilot Scale)	Dehusking
		Rice Sheller (Pilot Scale)	Milling
		Cabinet Dryer	Drying
		Baking Oven	Baking
		Dahl Grinder	Grinding
		Meat Mincer/Pulper	Micing
		Bowl Chopper	Chopping
		Sausage Stuffer	Stuffing
		Fruit Juice Extractor	Juice extraction from fruit
		Fruit Pulper	Pulping fruits
		Basket Presser	Pressing.
		Crown Corking Machine	Sealing
		Noodle Cutter	Sheeting and cutting
		Vacuum Packaging	Vacuum packaging
		Diesel Generator	Power supply
		Humidity Chamber	For shelf-life and germination
		Maize degerminator	Separation of hull, germ
		Refrigerator	Sample and reagent storage
		Cabinet Drier	Drying food commodities
		Mini Drier	Drying food commodities
		Copper distillation set	alcohol distillation
		Lab twin screw extruder	Extrusion
		Cheese ripening chamber	Ripening Cheese
		Centrifuge	Milling
		Microwave Dryer	Drying
		Vacuum Dryer	Drying
		Spray Dryer	Drying
		Steam Distillation Set	Distillation

Annex 2: Human Resources in 2081/82 (2024/25)

SN	Name	Position	Qualification	Specialization/Working area	Remark
1	Roman Karki	S-4, Chief	Master of Food Technology	Underutilized cereals, coffee, barley	
2	Pravin Ojha	S-2	M. Tech. (Food)	Food science	Deputed from NCARP,
3	Mahendra Maharjan	A-6		Account	
3	Janaki Giri	A-6	Masters in Management	Account	
4	Jayanti Koirala	A-5	B.A. LLB	Administration	
5	Rabina Bista	T (L- 2)	M.Ed. (EPM)	Laboratory Assistant	
6	Ranju Basnet	T (L- 2)	+2 (Arts)	Laboratory Assistant	Deputed from ARS, pakhribas
7	Rakshya Parajuli	T (L- 2)	+2	Laboratory Assistant	
8	Kabi Maharjan		SLC	Assist in food analysis and Account	Daily wages
9	Sunil Maharjan		+2	Assist in food analysis and Administration	Daily wages
10	Utshah Manandhar		Bachelor's degree in Food Tech.	Research Assistant	Daily wages
11	Kabina Karki		Bachelor's degree in Food Tech.	Research Assistant	Daily wages
12	Dewaki Rai		Bachelor's degree in Food Tech.	Research Assistant	Daily wages
13	Sanju Updhaya		Bachelor's degree in Food Tech.	Research Assistant	Daily wages
14	Arusha Basyal		Bachelor's degree in Food Tech.	Research Assistant	Daily wages
15	Ranju Parajuli		Bachelor's degree in Food Tech.	Research Assistant	Daily wages
16	Grishma Bidhya		Bachelor's degree in Food Tech.	Research Assistant	Daily wages
17	Sudikshya Bhattarai		+2 (Science)	Research Assistant	Daily wages
18	Sabhya Dhakal		+2 (Science)	Research Assistant	Daily wages
19	Sunayana Jonchhe		+2 (Science)	Research Assistant	Daily wages
20	Gita Bidhya			Supporting Staff	Daily wages
21	Anu Maharjan			Supporting Staff	Daily wages
22	Sangita Limbu Ekten		SLC	Supporting Staff	Daily wages
23	Raj Kumar Tamang		SLC	Driver	Daily wages
24	Parshuram Maharjan			Gardener	Daily wages

Annex 3: Summary Progress of NARC Research Projects and Activities in 2081/82 (2024/25)

Project code number.	Name of Project/Activity	Project/Activity Leader	End year	Budget allocated for this year ('000'	Major progress/achievements
1	**Farm Management and Research Support Project**	Dr. R. Karki		**4051**	
1.1	Assessment of physical, chemical, milling, cooking, qualities of cereals, legumes and oilseeds			688	**Paddy** Six samples of Paddy were obtained from National Agronomy Research Centre, Khumaltar. In functional analysis, cooking quality were determined. In chemical analysis, Amylose (g/100g), Iron (mg/100g), and Phosphorus (mg/100g) were determined. One sample of Paddy was obtained. In Physical Analysis 1000 kernet Wt., Bulk Density, L/B Ratio and Milling Analysis were determined. In Chemical analysis Moisture (%), Protein (%), Crude Fat (%), Total Ash (%), Iron (mg/ 100g), Calcium (mg/100g), Phosphorus (mg/100g), alkali spreading and cooking quality were determined. Two samples of paddy were received From National Plant Breeding and Genethic Research Centre, Khumaltar. In physical analysis, 1000 Kernel weight, L/B ratio, Bulk density and Cooking quality were determined in duplicate. In chemical analysis, Moisture (%), Fat (%), Protein (%), Crude Fiber (%), Total ash (%), iron (mg/100g) were determined in duplicate using NIR. Amylose activity (mu g/ml) and alkali spreading were determined in duplicate. **Paddy** 2 paddy samples were collected, in milling analysis brown rice (%), husk (%), milling recovery (%), bran (%) were analyzed. **Millet** A total of 2 samples were obtained from Hill Crop Research Program,

Dolkha. Physical parameters (1000 kernel, bulk density , L/B ratio), Moisture (%), Fat (%), Protein (%), Ash (%), Phosphorous (mg/100g), Crude fibre (%), Iron (mg/100g) and zinc (mg/100g) were determined.

Two paddy samples were obtained from National Plant Breeding and Genetic Research Centre, Khumaltar, Milling and iron (mg/100g) were analyzed.

Maize

Three samples of maize were obtained from National Plant Breeding and Genethic Research Centre. ,In physical Physical property, Germ (%), Peel (%) were analyzed. In chemical analysis Moisture (%), Protein (%), Fat (%), Crude Fiber (%) Ash (%) content and phosphorus (mg/100g) were analyzed.

Beans

One sample of Bean (Simi) was obtained from Agriculture Research Station, Jumla. In Physical Analysis, Length/Breadth ratio, Bulk Density (Kg/HL), 1000 Kernel Weight (g), Edible (%), and Non-edible (%) were determined. In chemical analysis, Moisture (%), Crude Fat (%), crude fiber, Total Ash (%), Protein (%), Iron (mg/100g), Calcium (mg/100g), and Phosphorus (mg/100g), Cooking Quality (%), Polyphenol (mg/100g) were determined in duplicate.

Four samples of beans were obtained *Kose bali aanusandhan Karikram, Khajura*. In physical analysis, bulk density, l/b ratio and 1000 kernel weight were determined. In chemical analysis, Moisture Content (%), Crude Fibre (%), Fat (%), Protein (%) Total Ash (%), Iron (mg/100g), Phosphorus (mg/100g) and Calcium (mg/100g) were determined in duplicate.

Products

Cereal Products

Three samples of Cereal Products were obtained from Kodi ventures. In chemical analysis, Moisture (%), Protein (%), Crude Fat (%), Total Ash (%), Crude fibre (%) and Antioxidant(% RSA) were determined in duplicate.

PROTEIN ISOLATE POWDER

			Five samples of Protein Powder were obtained from Himalaya Care Research and Remedies. In chemical analysis, Moisture(%), Protein (%) were determined. Six samples of protein isolate powder were received from Himalaya Care Research Remedies. In chemical analysis, Moisture (%) and Protein (%) were determined in duplicate. Three samples of protein isolate powder were obtained from Himalaya Care Research Remedies. In chemical analysis, moisture (%) and protein (%) were determined in triplicate. Protein powder one sample was received from Himalaya Care Research Remedies. Protein (%) was s. Eleven samples were Obtained from Biotechnology society of Nepal. In chemical analysis, Total Polyphenol Content, Total Flavonoid Content and Antioxidant activities were determined. **Methanolic extract** 11 samples of methanolic extract were received from biotechnology socity of nepal. Antioxidant activity, Polyphenlo content, Flavonoid contant, Total phenolic compound were carried out.
1.2	Chemical and nutritional analysis of horticulture crops	623	**<u>Fruits</u>** **APPLE** Six samples of Apples were obtained from Horticulture Research Centre, Jumla. In chemical analysis, Moisture (%), Total Ash (%), Crude Fibre , Protein (%) Acidity (%), TSS (°Bx), Phosphorus (mg/100g) and Calcium (mg/100g), Vitamin 'C' (mg/100g as Ascorbic Acid), Iron (mg/100g) and Reducing Sugar (mg/100g) were determined. ***JUNAR*, ORANGE AND LEMON** Four samples of *Junar*, one sample of Orange and one sample of lime were obtained from National Citrus Research Program. In chemical analysis, moisture (%) and Vitamin C (mg/100g) were determined. **<u>Vegetables</u>** **Spinach**

One sample of leafy vegetable (spinach) was received from NHRC, Khumaltar. In chemical analysis, Moisture (%) , Vitamin C (mg/100g) , Total carotenoids were determined in duplicate.

One sample of leafy vegetable (spinach) was received.In chemical analysis, Chlorophyll and T-carotenoid, Ash content were determined in duplicate.

Coffee

Twenty eight samples of dry green coffee beans were obtained from Coffee Research Program, Gulmi. In chemical analysis, Caffeine (ppm), Polyphenol (mg/100g), Flavonoid (mg/100g), Tannin (mg/100g), Antioxidant (% RSS) were determined using HPLC.

Potato

Five samples of Potato were obtained from National Potato Research Program.

In chemical analysis, Starch (%), Moisture (%) and Vitamin 'C' (mg/100g) content were determined.

<u>Spice</u>

Four samples of Spices was obtained from *Waling Aduwa tatha Krishi Upaj* Pvt Ltd., *Syanga* In chemical analysis, Moisture (%), Total Ash (%), Essential Oil (%), Total Starch (%), Lead Chromate , Chlorophyll a and b, Lycopene and Beta carotene test were in progress in duplicate.

Turmeric

Two samples of turmeric were obtained from agro *ilam*.In chemical analysis, moisture (%) and curcumin (%) were determined in duplicate.

Ginger

Eight samples of ginger were received from NCCRC, Khumaltar. In chemical analysis, Moisture content (%) , Crude fibre and Oleoresin (%) were determined in duplicate.

Eighteen samples of ginger were obtained from coffee research program. In chemical analysis, moisture (%), Crude fiber (%), Essential oil, Fat (%) were determined in triplicate.

CAPSICUM

			One Hundred and thirty four samples of Capsicum were obtained National Plant Pathology Research Centre. In chemical analysis, Moisture (%), Vitamin 'C' (mg/100g) and Acidity (%) were determined in duplicate of 35 samples. **<u>Nuts</u>** **Walnuts** Six samples of walnuts were obtained Horticulture Research Station. In chemical analysis, Moisture (%), and Fat (%), protein (%), Polyphenols, Flavonoids and Antioxidants , were determined in duplicate. **Macademia nut** Five samples of nuts were obtained from Horticulture Research Station, *Malepatan, Pokhara*. In chemical analysis, moisture (%) , iron, phosphorous, calciumwas determined in duplicate. **Tea** One Tea sample was obtained from DFTQC, *Babarmahal*. In chemical analysis, Moisture (% dwb), Total Ash (% dwb) and Water extract (% dwb). All the parameter were completed in triplicate.
1.3	Physical chemical and nutritional analysis of meat, fish, and poultry	608	**Fish sauce** Three samples were received from National Gishery Research Centre, godawari In chemical analysis, moisture(%), Protein (%), Ash (%), lipid and salt content were determined. Six samples of Fish sauce were received From National Fishery Research Centre, Godawari. In chemical analysis, Moisture (%) Protein (%), Nitrogen (%), Total volatile basic Nitogen (%), Total ash (%), Fat (%), Salt concentration (%) were done. **Fish Water** Eight sample of Fish Water was obtained from NDRC, Khumaltar. In chemical analysis, Geosmin (ppb) was determined using GCMS. **Black shoulder fly** Forty Five samples of Black Shoulder Fly Samples were obtained. In chemical analysis, Moisture (%), Iron (mg/100g) and Phosphorus (mg/100g) were determined in duplicate.

				Egg The eggs were subjected to freeze drying for albumin, yolk and whole egg. **Rumen** 49 rumen samples were obtained. In chemical analysis, Volatile fatty acids were determined using GC-MS. **Honey** Three wild honey samples was obtained. In chemical analysis, Moisture(%), and Hydroxymethyl Furfural (HMF) (mg/kg) were determined.
1.4	Office security		800	Office security has been maintained throughout the year
1.5	Office maintenance, support and beautification		996	Office has been aintained, and all other necessary requirement has been provided. Also beautification of the office has been maintained.
1.6	Participation in planning workshop, and national level conference and seminar		150	There was a participation of NFRC in different conference, and seminars.
1.7	Monitoring, evaluation and coordination with local government		186	Training on Mushroom processing, diversification , processing technique ,technology used for muchroom product preparation was given to local enterprenures by the cordination of local government.
879	**Development and verification of value addition technology in mushroom for Bagmati Province**	**Mr. P. Ojha**	**912**	
879.1	Development of value added technology of mushroom (Soup powder, mushroom pickle, dehydrated mushroom) and post-harvest solutions for mushroom to		465	Mushroom Powder Based Soup Mushroom powder based soup was prepared in Technology Incubation Unit and further analysis were carried out. In physical analysis, Dispersibility (%), Wettability (%), Water Retention Capacity (%), Caking Property (%), and Viscosity were determined in triplicate. Different formulation of mushroom powder based soup is being carried out after drying mushroom in Technology Incubation Unit. In chemical analysis,

	keep it fresh for 5-7 days			Moisture (%), Fat (%), Total Ash (%),, Protein (%), Iron (mg/100g), Calcium (mg/100g), and Phosphorus (mg/100g) of 10 different formulation of soup powder were performed. Two samples of mushroom were received from Bansun Jugedi Mushroom, Chitwan. In chemical analysis, Moisture (%), Antioxidant (mg/100g), Polyphenol (mg/100g), Flavonoid (mg/100g), Iron (mg/100g), Phosphorous (mg/100g) and Calcium (mg/100g) were determined in duplicate.
879.2	Onsite verification of developed technology from mushroom		447	Three days training on processing development and diversification of mushroom products and technology used to enterprenures
896	**Documentation, Standardization and Optimizing of Ethnic Food of Nepal**	**Dr. R. Karki**	**703.38**	
896.1	Isolation , characterization and evaluation of different mold and yeast stains used in traditional fermentation process		255	**Thakali set Ghandruk.** Seven cooked and seven raw samples were obtained from Ghandruk. **fresh sample** Moisture (%) , Fat (%), Protein (%) , ash (%) , Crude fibre (%), Iron (mg/100g), Calcium (mg/100g), Phosphorus (mg/100g) were analysis in progress. **Freeze dried** Moisture (%) , Fat (%), Protein (%) , ash (%) , Crude fibre (%), Iron (mg/100g), Calcium (mg/100g), Phosphorus (mg/100g) were analysis in progress. **Lovely hill thakali sample** 19 sample of Ethnic food were collected from Lovely hill, Pokhara. **fresh sample** Moisture (%) , Fat (%), Protein (%) , ash (%) , Crude fibre (%), Iron (mg/100g), Calcium (mg/100g), Phosphorus (mg/100g) were analysed. **Freeze dried** Moisture (%) , fat(%), Protein (%), ash(%), Crude fibre (%), Iron

(mg/100g), Calcium (mg/100g), Phosphorus (mg/100g) were analysed.

Pokhara fewa lakeside Thakali

29 sample of ethnic food were collected from Fewalake, Pokhara.

fresh sample

Moisture (%) , fat(%), Protein (%), ash(%), Crude fibre (%), Iron (mg/100g), Calcium (mg/100g), Phosphorus (mg/100g) were analysis in progress.

freeze dried sample

Moisture (%) , fat(%), Protein (%), ash(%), Crude fibre (%), Iron (mg/100g), Calcium (mg/100g), Phosphorus (mg/100g) were analysis in progress.

Yomari, Bhakka and Kaguno kheer

9 ethnic Food samples (yomari and raw materials) were collected from Maulik bhancha ghar. In chemical analysis moisture(%), Protein (%), fat (%), Iron were analysed . Phosphorus content of 3 samples was determined.

Chhaang

lot 1 Two different types of Chhaang was prepared using Two different types of murcha collected from Kathmandu Valley. The sample was Taken Out on different days 3,6, 9,12,15 and 18. In chemical analysis, TSS (˚Bx), pH, Acidity (%), and Alcohol (%), Volatile Acidity (%), Ester content (%), Reducing Sugar (mg/100g) were determined in triplicate.(in progress)

5 Samples of Jand were prepared with 5 different compositions with rice and broken rice.The alcohol content of the samples was measured.

Two different types of jand was prepared

murcha collected from Kathmandu Valley.In chemical analysis, TSS (˚Bx), pH, Acidity (%), Alcohol (%), Volatile Acidity (%), Ester content (%) and Reducing Sugar was determined in triplicate.

Khapse,

Five samples of Ethnic food were Collected from Rashuwa. In chemical analysis, Freeze dried, Proximate and Minerals. Protein (%) of 1 sample were done.

Murcha collected from Bhaktapur.

			In chemical analysis, TSS (˚Bx), pH, Acidity (%), Alcohol (%), Volatile Acidity (%), Ester content (%) was determined in triplicate of day 3, 6 , 9 , 12, 15, and 18 prepared using murcha collected from Bhaktapur. **<u>Millet</u>** Seven samples of millet were collected from NHRC, Mainapokhari . In physical analysis, L/B ratio, 1000 Kernel weight and Bulk density were determined in triplicate. **<u>Malt Rakshi</u>** Millet was malted, fermented using local methods, and then distilled to produce malt rakshi. **Raksi** Seven samples were collected. In chemical analysis, acidity, ester and volatile acidity were completed. **Ghongi** Two samples of ghongi (raw and cooked) were collected. In chemical analysis, moisture content (%), Ash (%), Protein (%) were determined for both raw and cooked sample in triplicate. **Bombaisan** One sample of dairy product (Bombaisan) was Collected. In chemical analysis, Moisture content (%) and Total Ash (%), Vit C were determined in triplicate. **MEL candey** Two samples of mel (raw and candy) were Collected. In physical analysis, L/B ratio and average weight of fruit (RM) was determined. In chemical analysis, Moisture (%), Fat (%), Fiber (%),,Protein (%), Iron (mg/100g) and Vit c (mg/100g) was determined in triplicate. **Chilli Products** Three samples of chilli product were collected.In chemical analysis, Moisture (%),,Fat (%), Vitamin C (mg/100g) and Acidity (%) was determined in triplicate and essential oil were determined.
896.2	Development of standard Products		7 different millet samples were collected from Dolkha and malted KMR were developed.

896.3	Quality evaluation and optimization standarized product			Proximate, mineral,nutrition retention of the raw ingredients and cooked ethnicsfood product is analyzed and studied.
897	**Application and Optimization of Extrusion Technology for the Development of Soybean based hybrid meat products, textured protein and meat analogues and fortified soya-cereal products**	**Dr. R. Karki**	**1250**	Soybased protein isolate has been prepared from the different varieties of soybean. Different trials have been done for optimizing the soybased products.
897.1	Assessment of physical, chemical, nutritional and functional quality of soyabean		415	**Soybean** Three samples of soybean was obtained from Pokhara. In chemical analysis, Moisture (%), Protein (%), Fat (%), Total Ash (%),Crude fibre (%), Antioxident, Polyphenol, Flavonoids, and Phosphorus (mg/100g) were determined. All data were performed in Triplicate. Two samples of Soybean (white and black) were collected. In Physical Analysis, Length/Breadth ratio, Bulk Density (kg/HL), 1000 Kernel Weight (g), Edible (%), and Non-edible (%) were determined. In chemical analysis, Moisture (%), Protein (%), Crude Fat (%), Crude Fibre (%), Total Ash (%), calcium (mg/100g), Iron (mg/100g), and Phosphorus (mg/100g) was determined in duplicate.was determined in duplicate.
897.2	Preparation of textured soya products		475	Tradition Kinema was prepared using different Varities of Soybeans. Isolate was prepared using Soybean.
897.3	Optimization of soya products		360	**Kinema** Three types of kinema was prepared in Technology Incubation Unit of three types of soybean. The prepared kinema were freeze dried.

				In chemical analysis, Moisture (%), Polyphenol (mg/100g), Flavonids (mg/100g), and Antioxidant (% RSA) were determined in triplicate. Kinema prepared from Brown soybean were freeze dried from Day 1 to day 6. In chemical analysis, Moisture (%), Polyphenol (mg/100g), Flavonids (mg/100g), and Antioxidant (% RSA) was determined in triplicate of kinema prepared from brown soybean from day 1 to day 6. Trial of amino acids determination of black kinema by HPLC and Polyphenol and Flavonoid content were derermined. **Kinema meat pickle** 9 types of kinema meat pickle were prepared.In chemical analysis, Moisture (%), Protein (%), Fat (%), Crude Fibre (%), and Total Ash(%) were performed in triplicate.
898	**Nutritional and Glycemic index properties of high-altitude cereal crops**	**Mr. P. Ojha**	**1710**	
898.1	Effect of degree of milling and processing in the starch and glycemic properties of rice		426	**Paddy** Three samples of paddy were collected. In physical analysis, Bulk density and 1000 kernel weight were completed. **Millet** Seven millet samples were collected. Physical analysis were completed and the obtained millet was grinded into flour. Dhido was prepared. Moisture (%), Fat (%), Ash (%), protein (%) of both raw and cooked millet were determined. **Simal Tarul and Corn Starch** Simal Tarul starch was prepared in Technology Incubation Unit and further analysis were carried out. Trial for film making using Conr starch, Glycerol, and Bentonite was carried out in Laboratory. In chemical analysis, Moisture (%), Total Starch (%), and Hygroscopisity (adsorbed moisture/100g dry solid) were determined of corn starch and simal tarul starch.

898.2	Effect of processing (Cooking technology) in the starch and glycemic properties of rice of other cereals than rice.		448	millet sample were cooked. Proximate analysis of Raw and cooked millet were analyzed. sample of paddy were milled in 5 different degree of milling. All the milled rice were cooked in different cooking processing.
898.3	Effect of processing on the micronutrients (iron, zinc, copper, sodium, potassium, calcium) of cereals		448	Ten samples of paddy were obtained.In physical analysis, L/B ratio, 1000 kernel weight, Bulk density, Milling (%), Husk (%), Degree of milling were performed. In chemical analysis, Moisture (%) was determined in triplicate.
	Effect of processing on surface morphology and microstructure of cereals and its relation to glycemic properties		421	Morphology and microstructure of raw and cooked rice of different varieties using different processing (cooking technology) was studied using SEM (Scanning Electron Microscope).
899	**Chemical and textural quality changes in cheese ageing and packaging intervention**	**Mr. P. Ojha**	**725**	
899.1	Study the chemical and textural changes associated with cheese ripening		370	**Goat Cheese** Ten samples of Goat Cheese was obtained from National Goat Research Program, Bandhipur. In chemical analysis, moisture (%), Fat (%), Protein (%), Iron (mg/100g), Calcium (mg/100g) and Texture were determined in duplicate. Ten Samples were received from National Goat Research Program, Bandipur. In chemical analysis, moisture (%) was determined in duplicate. **Cheese** One sample of Cheese was obtained from Bandipur In chemical analysis,

				Protein (%) , Iron (mg/100g) were determined in duplicate. (NFRC/2412/08) 081/82/32-Three samples of cheese were Collected. In chemical analysis, Moisture (%) was determined in triplicate.
899.2	Development of biodegradable plastic from maize, and yam		355	Biodegradable plastic Different trials of plastic formation were carried out as per RSM after successful trial completion.. Starch was extracted from Casava for the preparation of biodegradable plastic.
1087	**Exploring genetic diversity, breeding and good management practices Processing, value addition, and geographical indication indicators of cardamom.**	**Dr. R. Karki**	**1431**	**Essential Oils were extracted and volatile profile of the extracted oils were analysed. Bioactive compounds of the samples were analysed.**
1087.1	Conservation through field gene bank and tissue bank		60	different verities of cardamom were collected and dried by different drying techniques.
1087.2	Agro-morphological and genetic ditersity assessment		80	Physical properties,proximate, mineral and bioactive properties of different varieties of large cardamom were determined.
1087.3	Conduct a comprehensive analysis of existing traditional drying methods		555	**Large Cardamom** Five varieties of Large Cardamom were collected from Pakhribas. In physical analysis, Freeze dried, Cabinet dried, and Hybrid dried samples were subjected to L/B ratio, and Yield (%). In chemical analysis, Moisture content (%), and Essential Oil (%), Volatile fatty acid profiling of the essential oil, Polyphenol (mg/100g), Flavonoid (mg/100g) and Antioxidant (mg/100g of Freeze dried, Cabinet dried, and Hybrid dried were analysed. Three samples of Cardamom were collected. In chemical analysis, Physical property, Proximate,

			Bioactive and Essential oil, Volatile fatty acid profiling of the essential oil were done.determined in triplicate. Ten samples of large cardamom were Collected. In chemical analysis, Essential oil, Volatile fatty acid profiling of the essential oil was determined in duplicate.
1087.4	Investigate the drawbacks and limitations associated with	581	Drawback and limitation associated with production, processing of large cardamom was studies and analyzed.
1087.5	Conduct in-depth analyses comparing economic aspects, including production costs, market prices, and financial implications, for different large cardamom drying and processing methods	155	In-dept study was conducted on production costs, market prices, and financial implications, for different large cardamom drying and processing methods.

Annex 4a: Training/Workshop/Seminar Organized in FY 2081/82 (2024/25)

SN	Name of Training/ Workshop/ Seminar	Duration	Target group	Location	No. of participant
1	"*Chyauko Parikar Bikas Tatha Anya Khadya Bibidhikaran*"	3 days	Farmers	NFRC, Khumaltar	20

Annex 4b: List of participants, on "*Chyauko Parikar Bikas Tatha Anya Khadya Bibidhikaran*" in FY 2081/82 (2024/25)

Location: National Food Research Centre, Khumaltar, Lalitpur

SN	Participants name	Address
1	Kiran Bahadur Khadka	Dolakha
2	Shree Ram Shrestha	Dolakha
3	Bishnu Prashad Poudel	Bardiya
4	Subarna Maharjan	Balambu
5	Sanjay Dev Maharjan	Balambu
6	Muna Subedi	Rautahat
7	Gauri Devi Shah	Rautahat
8	Chadani Kumari	Rautahat
9	Prince Shah	Rautahat
10	Rama Shrestha	Balambu
11	Surendra Giri	Chandragiri
12	Baburam Bika	Bardaghat
13	Binod Mahato	Mahottari
14	Ajaya Kumar Singh	Dhanusha
15	Gun Kumar Timalsina	Rautahat
16	Purna Prashad Timalsina	Rautahat
17	Depak Prashad Neupane	Gaidakot, Nawolparasi
18	Shankar Prashad Neupane	Palpa, Tansen
19	Arpana Bhujel	Palpa, Tansen
20	Rajendra Panthi	Arghakhanchi

Annex 5: Laboratory Testing Service at National Food Research Centre

नेपाल कृषि अनुसन्धान परिषद्
राष्ट्रिय कृषि अनुसन्धान प्रतिष्ठान
राष्ट्रिय खाद्य अनुसन्धान केन्द्र
खुमलटार, ललितपुर

आ.ब. ०८१/८२

विश्लेषण दस्तुर (खाद्य पदार्थ)

यस केन्द्रमा तपशिलमा उल्लेखित खाद्य वस्तुहरुको प्रयोगशाला विश्लेषण गर्न सकिने छ । यस प्रकारको विश्लेषण सेवाहरुको हकमा यस केन्द्रको नियमित परियोजनाहरुको कार्य सम्पादन बाट अतिरिक्त रहेको समयमा पूर्व जानकारी गराई नियमानुसार परिक्षण दस्तुर बुझाई, खाद्य वस्तुको नमुना प्रयोगशालामा प्राप्त भएपछि परिक्षणका प्रकार हेरि बढिमा ३० दिन भित्र नतिजा उपलव्ध हुनसक्ने छ ।

तालिका

सि.नं.	खाद्य पदार्थ	परिक्षण दस्तुर नार्क, कृषक
1	तरल दध (fat, SNF, Acidity)	१२००
2	शृक्ष्म जीव TPC, Yeast/Mold	२४००
3	जलांश (Moisture) /सुख्खापनको मात्रा (dry matter)	२००
4	प्रोटिन (Protein)	४००
5	Total Sugar, Reducing sugar	४००
6	स्टार्च (Starch)	४००
7	चिल्लो पना (Ether extract) Fat	५००
8	भष्म (Ash)	३००
9	मिनरल : Fe, Ca, P, k प्रत्यक	६००
10	भिटामिन 'C'	६००
11	अम्लता (Acidity)	२००
12	क्षारियता pH	२००
13	क्रुड फाइवर (Crude Fibre)	६००
14	पानीमा घुलनशिल भष्म (Water Soluble Ash)	३००
15	एसिडमा नघुल्ने भष्म (Acid Insoluble Ash)	३००
16	क्याफिन	६००
17	पुर्णघुलनसिल ठोस पदार्थ (°BX) Total Soluble solids	१००
18	Pulp content/Juice content	१००
19	उड्ने तेल (Volatile Oil/ essential oil)	५००
20	करक्यूमिन	५००
21	सबै खाद्यान्न बालीको भोतिक परिक्षण (सेप, साइज, बल्क डेन्सिटी, १००० दानाको तौल	३००
22	धानको मिलिङ्ग एनालाइसिस (Milling recovery, Head rice yield)	५००
23	गहुँको मिलिङ्ग एनालाइसिस (Flour percentage)	२००
24	एमाइलोज टेष्ट (Amylose test)	६००
25	Alkaline Spreading Test (Rice)	२००

सि.नं.	खाद्य पदार्थ	परिक्षण दस्तुर नार्क, कृषक
26	ग्लुटिन टेष्ट (Dry)	५००
27	ग्लुटिन टेष्ट (Cooking Quality) Cooking time, Gruel loss	८००
28	Cooking loss of Meat, Fish & Poultry	२००
29	Antioxidant activity	१०००
30	Polyphenol content	१०००
31	Flavonoid content	१०००
32	Carotenoids	१०००

१. कलेजका विद्यार्थीहरुले अवलोकन तथा व्यवहारिक ज्ञान लिने सम्बन्धमा एक दिनको लागि रु. ३००० ।- (तिन हजार) सम्वन्धित कलेजले बुझाउनु पर्ने ।

२. तालिमको हकमा प्रशिक्षण हेण्ड आउट २००० ।- (दुई हजार), विषय विशेषज्ञ रु १०००० ।((दश हजार) प्रति दिन तथा प्राविधिक शूल्क रु.२००० ।- (दुई हजार) प्रति दिन तालिम सामाग्री खर्च सम्बन्धित व्यक्तिरसंस्थाले व्यवस्था गर्नु पर्ने छ ।

३. सरकारी तथा दातृ संस्थाबाट आएमा क्रमश रु १०,००० ।- (दश हजार) र ६,००० ।-(६ हजार) विशेष विशेषज्ञ र प्राविधिक शूल्क प्रति दिन लाग्ने छ अन्य आवश्यक तालिम सामाग्री कच्चा पदार्थ केमिकल सम्बन्धि व्यक्तीरसंस्थाले व्यहोर्नु पर्नेछ ।

४. माथी उल्लेखित राजस्व वाहेक आवश्यकता परेको अवस्थामा सो संग सम्बन्धित रासायन तथा ज्यामीको दर पनि सोहि संस्थाले ब्यहोर्नु पर्ने ।

FEDERATION FOR DEVELOPMENT OF ACCREDITATION SERVICES

118-119, First Floor, Sushant Tower, Sector – 56, Gurugram – 122011, Haryana, India.

CERTIFICATE OF ACCREDITATION

(AS PER ISO/IEC 17025:2017)

This is to attest that

NATIONAL FOOD RESEARCH CENTRE.

Khumaltar, Lalitpur, Nepal

Testing Laboratory

has demonstrated compliance with ISO/IEC Standard 17025:2017, General requirements for the competence of testing and calibration laboratories, and supplementary criteria for testing laboratories.

Certificate Number: TL-151

Issue Date: 09.07.2025 **Valid Until**: 08.07.2027

The certificate remains valid for the Scope of Accreditation as specified in the annexure subject to continued satisfactory compliance to the above standard and the relevant requirements of FDAS. (for scope of accreditation visit website www. fdasindia.org).

DEVI SARAN TEWARI

Director

FEDERATION FOR DEVELOPMENT OF ACCREDITATION SERVICES

118-119, First Floor, Sushant Tower, Sector – 56, Gurugram – 122011, Haryana, India.

SCOPE OF ACCREDITATION

(Annexure to Certificate of TL-151)

Laboratory Name: National Food Research Centre
Khumaltar, Lalitpur, Nepal

Validity: 09.07.2025 to 08.07.2027 **Amended on** N/A

Chemical Testing (Laboratory Based)

S. No.	Material/Products	Component /Parameter/ Characteristic Tested	Test Method	Equipment Used
Group: Food and Agricultural Products				
1.	Cereals (Rice, Maize, Wheat, Buckwheat, Millet, Amaranth, Sorghum)	Moisture (%)	Hot Air Oven Method, AOAC official Method 925.09 B: 2023	----
		Crude Protein (%)	Kjeldahl Method, AOAC official Method 992.23: 2023	----
		Crude Fat (%)	Soxtech Fat Analyzer, AOAC official Method 920.39C: 2023	----
		Crude Fiber (%)	Fritted Glass Crucible Method, AOAC official Method 962.09E: 2023	----
		Total Ash (%)	Muffle Furnace Method, AOAC official Method 923.03: 2023	----
		Iron (mg/100g)	Atomic Absorption Spectrophotometry Method, AOAC official Method 999.10: 2023	AAS
		Calcium (mg/100g)	Atomic Absorption Spectrophotometry Method, AOAC official Method 999.10: 2023	AAS
		Phosphorus (mg/100g)	Spectrophotometric Molybdovanadate Method, AOAC official Method 970.39: 2023	UV-Spectrophotometer
2.	Legumes (Soybean, Lentils, Beans)	Moisture (%)	Hot Air Oven Method, AOAC official Method 925.09B: 2023	---
		Crude Protein (%)	Kjeldahl Method, AOAC official Method 920.87: 2023	----

Jitendra Parmar
Dealing Officer

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Chemical Testing (Laboratory Based)

S. No.	Material/Products	Component /Parameter/ Characteristic Tested	Test Method	Equipment Used
		Crude Fat (%)	Soxtech Fat Analyzer, AOAC official Method 920.39C: 2023	----
		Crude Fiber (%)	Fritted Glass Crucible Method, AOAC official Method 962.09E: 2023	----
		Total Ash (%)	Muffle Furnace Method, AOAC official Method 923.03: 2023	----
		Iron (mg/100g)	Atomic Absorption Spectrophotometry Method, AOAC official Method 999.10: 2023	AAS
		Calcium (mg/100g)	Atomic Absorption Spectrophotometry Method, AOAC official Method 999.10: 2023	AAS
		Phosphorus (mg/100g)	Spectrophotometric Molybdovanadate Method, AOAC official Method 970.39: 2023	UV-Spectrophotometer
3.	Fruits (Apple, Banana, Orange, Sweet orange, Lime, Pear, Plum)	pH	pH meter, AOAC official Method 981.12: 2023	----
		Acidity (%)	Titrimetric Method, AOAC official Method 942.15: 2023	----
		Moisture (%)	Hot Air Oven Method, AOAC official Method 934.06: 2023	----
		Crude Protein (%)	Kjeldahl Method, AOAC official Method 920.87: 2023	----

Jitendra Parmar
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Khumaltar, Lalitpur, Nepal

Validity: 09.07.2025 to 08.07.2027 **Amended on** N/A

Chemical Testing (Laboratory Based)

S. No.	Material/Products	Component /Parameter/ Characteristic Tested	Test Method	Equipment Used
		Crude Fat (%)	Soxtech Fat Analyzer, AOAC official Method 920.39C: 2023	----
		Crude Fiber (%)	Fritted Glass Crucible Method, AOAC official Method 962.09E : 2023	----
		Total Ash (%)	Muffle Furnace Method, AOAC official Method 940.26 : 2023	----
		Iron (mg/100g)	Atomic Absorption Spectrophotometry Method, AOAC official Method 999.10 : 2023	AAS
		Calcium (mg/100g)	Atomic Absorption Spectrophotometry Method, AOAC official Method 999.10 : 2023	AAS
		Phosphorus (mg/100g)	Spectrophotometric Molybdovanadate Method, AOAC official Method 970.39 : 2023	UV-Spectrophotometer
4.	Vegetables (Spinach, radish, Capsicum, Cabbage, Lettuce, Cauliflower)	pH	pH meter, AOAC official Method 981.12 : 2023	----
		Acidity (%)	Titrimetric Method, AOAC official Method 942.15 : 2023	----
		Moisture (%)	Hot Air Oven Method, AOAC official Method 934.06 : 2023	----
		Crude Protein (%)	Kjeldahl Method, AOAC official Method 920.87 : 2023	----
		Crude Fat (%)	Soxtech Fat Analyzer,	----

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(Annexure to Certificate of TL-151)

Laboratory Name: National Food Research Centre
Khumaltar, Lalitpur, Nepal

Validity: 09.07.2025 to 08.07.2027 **Amended on** N/A

Chemical Testing (Laboratory Based)

S. No.	Material/Products	Component /Parameter/ Characteristic Tested	Test Method	Equipment Used
			AOAC official Method 920.39C : 2023	
		Crude Fiber (%)	Fritted Glass Crucible Method, AOAC official Method 962.09E : 2023	----
		Total Ash (%)	Muffle Furnace Method, AOAC official Method 940.26 : 2023	----
		Iron (mg/100g)	Atomic Absorption Spectrophotometry Method, AOAC official Method 999.10 : 2023	AAS
		Calcium (mg/100g)	Atomic Absorption Spectrophotometry Method, AOAC official Method 999.10 : 2023	AAS
		Phosphorus (mg/100g)	Spectrophotometric Molybdovanadate Method, AOAC official Method 970.39 : 2023	UV-Spectrophotometer
5.	Tubers (Potato, Sweet potato, Cassava, Taro, Yam)	Moisture (%)	Hot Air Oven Method, AOAC official Method 934.06 : 2023	----
		Crude Protein (%)	Kjeldahl Method, AOAC official Method 920.87 : 2023	----
		Crude Fat (%)	Soxtech Fat Analyzer, AOAC official Method 920.39C : 2023	----
		Crude Fiber (%)	Fritted Glass Crucible Method, AOAC official Method 962.09E : 2023	----

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Khumaltar, Lalitpur, Nepal

Validity: 09.07.2025 to 08.07.2027 **Amended on** N/A

Chemical Testing (Laboratory Based)

S. No.	Material/Products	Component /Parameter/ Characteristic Tested	Test Method	Equipment Used
		Total Ash (%)	Muffle Furnace Method, AOAC official Method 940.26 : 2023	----
		Iron (mg/100g)	Atomic Absorption Spectrophotometry Method, AOAC official Method 999.10 : 2023	AAS
		Calcium (mg/100g)	Atomic Absorption Spectrophotometry Method, AOAC official Method 999.10 : 2023	AAS
		Phosphorus (mg/100g)	Spectrophotometric Molybdovanadate Method, AOAC official Method 970.39 : 2023	UV-Spectrophotometer

Jitendra Parmar
Dealing Officer

Annex 6: Publications in FY 2081/82 (2024/25)

SN	Name of publication	Type	Language	Authors	No	Publisher
1	Annual Report 2080/81	Book	English	NFRC	100	National Food Research Centre (NFRC), NARC
2	Nepal Food Composition Database	Book	English	NFRC	200	National Food Research Centre,

Annex 7: Academic Supervisions, FY 2081/82 (2024/25)

SN	Thesis Topic	Level	University	Supervisor / Facilitator	Research student
1	Development and Quality assessment of pickle product from optimally dried mushroom verities.	B.Tech. Food	T. U	Pravin Ojha	Trishna Baniya
2	Optimization of *thon* processing and broken rice percentage for optimal sensory quality	B.Tech. Food	P.U	Dr. Roman Karki	Grishma Baidya

Annex 8: Training/Workshop/Seminar Attended by Staff in 2081/82 (2024/25)

SN	Name of staff	Position	Name of Training / seminar/ workshop/meeting	Duration (days)	Place/ Country	Organizer
1	Dr. Roman Karki	Senior Scientist, Chief (S-4)	Quality Improvement of Asian Food Composition Database: Nepal Country Report.	5	Philippines	Asian Food and Agriculture Initiative (AFAC),
2	Dr. Roman Karki	Senior Scientist, Chief (S-4)	Nepal's Citrus Agriculture: Production, Standards, and Export Potential to China.	5	China	Institute of Quality Standard and Testing Technology of Agro-Products, Sichuan Academy of Agricultural Science (SAAS).

Annex 9: List of Publications at National Food Research Centre 2081/82 (2024/25)

SN	Title of publication	NARC Publication Serial Number	Year	Language	Published by
1	Nepal Food Composition Database	NPSN: 005/081/82	2081	English	NFRC, NARC,AFACI
2	Development of Locally Appropriate GAP Programs and Agricultural Produce Safety Information System		2081	English/Nepali	NFRC, NARC,AFACI
3	Standard Operating Procedure for Food Sampling and analysis	NPSN: 119/079/80	2080	English	NFRC, NARC
4	Manual of Weaning Food Developed from Malted Barley	NPSN: 054/078/79	2078	Nepali/English	NFRC,NARC, AFACI
5	Barley Product Technology Manual	NARC publication serial No. 00781-795/2020/021)	2077	Nepali/English	NFRC
6	Good Agricultural Practices (GAP) and Package of Practices of Cardamom)	(NARC publication serial No. 00711-525/2018/019	2075	Nepali	FRD, NARC, AFACI
7	Asal Krishi Abhyas: Parichay ra Praminikaran (Good Agricultural Practices: Introduction and Certification)	NARC publication serial No. 00794-608/2018/019)	2075		FRD, NARC, AFACI
8	Saagpaat kheti prabidhi ra Asal Krishi Abhyas(Package of practices and Good Agricultural Practices (GAP) of Leafy Vegetables)	(NPSN: 00561-374/2017/18)		Nepali	MoA-GON, FRD, NARC, AFACI
9	Coffee Prasodhan Tatha Utpadanoparant Prabidhi" (Coffee processing and post-harvest technology)	NARC publication serial No. 00458-271/2016/017)		Nepali	FRD
10	"Kiwi, Naspati Tatha Arubakhada Ko	(NARC publication		Nepali	FRD

SN	Title of publication	NARC Publication Serial Number	Year	Language	Published by
	Utpadanoparant Tatha Mulya Abhibriddhikaran Paddati" (Post-harvest and Value Addition Methods of Kiwi, Pear, and Plum)	serial No. 00452-265/2016/017)			
11	"Cauli Tatha Brocauli Kheti Ra Asal Krishi Abhyas" (Package of Practices and Good Agricultural Practices (GAP) of Cauliflower and Brocolli)	(NARC publication serial No. 00471-284/2016/017)		Nepali	FRD
12	"Banda Kheti Prabidhi Ra Asal Krishi Abhyas" (Package of Practices and Good Agricultural Practices (GAP) of Cabbage.	(NARC publication serial No. 00385-198/2016/017)		Nepali	FRD
13	"Digo Krishi Vikash Ko Lagi Asal Krishi Abhyas" (Good Agricultural Practices (GAP) for Sustainable Agriculture Development	(NARC publication serial No. 00367-180/2016/017)		Nepali	FRD
14	AFACI project on the development of national GAP programmes and agricultural produce safety information system	00187-001/2015/16	2072	English	FRD, DFTQC
15	Asal Krishi Abhyas Haru (Good Agricultural Practices (GAP) Training Manual (Bali-Chiya Tea)	-	2072	Nepali	FRD, DFTQC, AFACI
16	Asal Krishi Abhyas Haru (Good Agricultural Practices (GAP) Training Manual (Bali-Coffee (Coffee)	-	2072	Nepali	FRD, DFTQC, AFACI
17	Chino Tatha Kaguno Bata Biscuit, Cake Banaune Prabidhi	-	2071	Nepali	FRD
18	Food Research Division: An Introduction	-	2070	English	FRD

SN	Title of publication	NARC Publication Serial Number	Year	Language	Published by
19	Khadya Anusandhan Mahasakha: Ek Samchhipta Parichaya		2070	Nepali	FRD
20	Fact Sheet: Food Research Division		2070	English	FRD
21	Sthaniya Star Ma Machha Skaune Prabidhi		2070	Nepali	FRD
22	Supari: Parichaya, Utpadanoparant Noksan Tatha Prasodhan		2069	Nepali	FRU
23	Aalu Ko Pitho Banaune Prabidhi Tatha Upayog (Technology of Potato Flour and Uses)		2068	Nepali	FRU
24	Phapar Tatha Kodo Bata Pauroti, Biscuit, ChauchauBanaune Prabidhi			Nepali	FRU

Annex 10: Regular Annual Budget and Expenditure Record of FY 2081/82 (2024/25)

Budget code	Budget heads	Annual budget	Budget released	Expenses	Balance
	Staff Expenses	**6774000.00**	**6774000.00**	**4089641.90**	**2684358.10**
21111	Basic salary expenses	6332000.00	6332000.00	3859041.90	2472958.10
21113	Allowance	264000.00	264000.00	138000.00	126000.00
21121	Uniform expenses	110000.00	110000.00	50000.00	60000.00
21134	Meeting Allowance	15000.00	15000.00	15000.00	0.00
21213	Insurance	53000.00	53000.00	27600.00	25400.00
	Administrative Expenses	**1405000.00**	**1405000.00**	**1303529.00**	**101471.00**
22111	Water and Electricity	175000.00	175000.00	174236.00	764.00
22112	Communication expenses	88000.00	88000.00	75960.00	12040.00
22213	Repair and maintenance	300000.0	300000.0	292157.00	7843.00
22214	Insurance	60000.00	60000.00	38552.00	21448.00
22221	Mechinery & Equp. mainte.	220000.00	220000.00	219976.00	24.00
22231	Farm maintenance expenses	60000.00	60000.00	59769.00	231.00
22311	Office expenses	150000.00	150000.00	149800.00	200.00
22314	Generator fuel	52000.00	52000.00	50075.00	1925.00
22315	Paper, Publication	104000.00	104000.00	79889.00	24111.00
22711	Miscellaneous	70000.00	70000.00	69455.00	545.00
28143	Vehical & Machinery Lease	1260000.0	1260000.0	93660.00	1166340.00
	Operational Expenses	**10909000.00**	**10909000.00**	**10278755.00**	**630245.00**
22211	Vehicle fuel expenses	820000.00	820000.00	679508.00	140492.00
22313	Books and others	187000.00	187000.00	186061.00	939.00
22521	Wages to laborers	5756000.00	5756000.00	5755494.00	506.00
22521	Laboratory supplies	2085000.00	2085000.00	2084838.00	162.00
22521	Farm supplies	615000.00	615000.00	614252.00	748.00
22611	Monitoring & Evaluation Exp.	206000.00	206000.00	124985.00	81015.00
22612	Travel expenses	1240000.00	1240000.00	833617.00	406383.00
	Capital Expenses	**12800000.00**	**12800000.00**	**11899946.32**	**900053.68**
31122	Equipment, machinery and tools	12800000.00	12800000.00	11899946.32	900053.68
	Grand Total	**31888000.00**	**31888000.00**	**27571872.22**	**4316127.78**

Annex 11: Special Project Budget and Expenditure Record of FY 2081/82(2024/25)

Name of the project	Funded by	Project period	Annual budget	Expenses	Balance
"Establishment of Asian Composition Database (AFCD)"	Asian Food and Agriculture Cooperation Initiative (AFACI), Research and Development of Agriculture (RDA), Korea	2081/082	811825.36	615468.00	196357.36
Mitigating Soilborne Diseases to Impuove Smallholder Farmer Livelihoods and food Secrity in Nepal””	Feed the Future-Horticulture Innovation Lab, University of California Davis	2081/082	1001097.00	64100.00	936997.00
“Establishnment of Asian Food Composition Database”	Asian Food and Agriculture Cooperation Initiative (AFACI), Research and Development of Agriculture (RDA), Korea	2081/082	8628000.00	6536717.09	2091282.91

Annex 12: Revenue Status of FY 2081/82 (2024/25)

Code/Source	Trimester				Total income in this FY (NRs)	Remarks
	I	**II**	**III**	**IV**		
5500 Research income	7800.00	3000.00	104900.00	220500.00	336200.00	
5600 Other administrative income	0.96	19000.00	00.0	00.00	19000.96	
Total	**7800.96**	**22000.00**	**104900.00**	**220500.00**	**355200.96**	

Annex 13: Beruju Status of FY 2081/82 (2024/25)

Beruju	Amount (Rs.000)	Remarks
Beruju till last year	54	
Beruju cleared this FY	5	Clearance of Beruju
Remaining Beruju	49	Document processed for Clearance of Beruju

Annex 14: राष्ट्रिय खाद्य अनुसन्धान केन्द्रको प्रस्तावित संगठनात्मक ढांचा

प्रमुख-एस ५

१ पाईलट प्लान्ट
१.एस ३-१ जना
२.एस १-१ जना
३.टी ६-१ जना
४.टी ५-१ जना
५.प्रा.सह.-१ जना

२ खाद्यान्न तथा तेलहन बालीको लागि उत्पादनोपरान्त प्रविधि
१.एस ३-१ जना
२.एस १-१ जना
३.टी ६ -१ जना
४.टी ५-१ जना
५.प्रा.सह.-१ जना

३ वागवानी बालीको लागि उत्पादनोपरान्त प्रविधि
१. एस ३-१ जना
२.एस १-१ जना
३. टी ६-१ जना

४ चिया कफी र मसला बाली को लागि उत्पादनोपरान्त प्रविधि
१.एस ३-१ जना
२. एस १ -१ जना
३. टी ६ -१ जना
४. टी ५-१ जना
५.प्रा.सह.-१ जना

५ दुग्ध तथा मासु जन्य पर्दाथको उत्पादनोपरान्त प्रविधि
१.एस ३-१ जना
२.एस १ -१ जना
३.टी ६ -१ जना

६ खाद्यान्न विश्लेषण तथा माईक्रो वाईलोजी प्रयोगशाला
१. एस ३-१ जना
२. एस १ -२ जना
३. टी ६ -२ जना
४. टी ५-२ जना
५. प्रा.सह.-१ जना

७ लेखा, प्रशासन /स्टोर
१.लेखापाल-१ जना
२.प्रशासन/ स्टोर -१ जना

प्रस्तावितजम्मा दरबन्दी

पद	संख्या	पद	संख्या
एस ५	१	प्रा.सहयोगी	३
एस३	६	लेखा	१
एस १	६	प्रशासन, स्टोर	१
टी ६	६	पाले	१
टी ५	४		
जम्मा			२९

नोटः टि-५ कोहकमा न्युनतम योग्यता मान्यता प्राप्त शिक्षण संस्थाबाट क्षत्भअज (Food Technology) उत्तिर्ण गरेको हुनुपर्ने

Major technology and information available at National Food Research Centre

SN	Year	Technology and information
1	2052/53	Storage of fresh mushroom in cool chamber.
2	2059/60	Potato chips from different varieties of potato.
3	2060/61	Preparation of nutritious supplementary protein energy rich snacks food based on finger millet.
4	2063/64	Apple juice concentrates.
5	2065/66	Technology on preparation of bread, biscuit and noodles from buckwheat and millet.
6	2065/66	Dehydration of buffalo meat.
7	2065/66	Effect of drying and milling on yield of head rice in paddy.
8	2066/67	Potato flour, utilization.
9	2066/67	Technology on preparation of mango pulp concentrates.
10	2066/67	Technology on preparation of papaya cherry, papaya candy.
11	2067/68	Banana juice, banana nectar and banana candy.
12	2068/69	Technology development for the easy separation of betel nut husk manually or mechanically.
13	2068/69	Technology on betel nut products diversification.
14	2068/69	Nutritional quality analysis in maize and QPM with tryptophan and lysine analysis.
15	2068/69	Preparation of biscuits from proso millet and foxtail millet.
16	2069/70	Extension of storage life of strawberry and tomato upto 20 days.
17	2069/70	Improvement of dry meat and sekuwa quality by using papaine.
18	2069/70	Development of processing technology in lentils and pigeon pea for high recovery.
19	2069/70	Fish preservation by salting, drying and smoking.
20	2070/71	Fish preservation by canning.
21	2070/71	Preparation of biscuit and cake from amaranth and sorghum.
22	2070/71	Preparation of weaning food from malted Chino and Kaguno.
23	2071/72	Ripening conditions for banana and mango have been optimized.
24	2071/72	Guidelines of the GAP for Tea and Coffee have been developed.
25	2072/73	Preparation of value-added products from plum, pear. kiwi, turmeric and ground apple
26	2073/74	Appropriate coffee processing technology for quality improvement
27	2074/75	Information on good agricultural practices and package of practices of GAP on cabbage, cauliflower, leafy vegetables and cardamom cultivation/production
28	2075/76	Value added product technology of Apricot. Sweet orange peel incorporated cake
29	2076/77	Buckwheat tea, Snack bar from nus crop
30	2077/78	Dried sweet orange slice
31	2078/79	Weaning Food from Malted Barley
32	2079/80	Mushroom powder
33	2080/81	Kinema, kinema-Meat Pickle, Goat Cheese Optimal Processing, Goat Cheese Optimal Processing, Mushroom soup powder.
34	2081/82	Microwave drying of *Akbare* chilli
35	2081/82	Freeze drying of large cardamom