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STUDY ON "DEVELOPMENTANDNUTRITIONAL EVALUATION OF BETELLEAF LADDU"

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ABSTRACT

Betel leaf (Piper betle L.) is a medicinal plant extensively utilized in traditional Indian medicine, recognized for its antioxidant, antimicrobial, anti-inflammatory, and antidiabetic properties. This study aimed to create a functional laddu enriched with betel leaf powder and assessitsnutritional,phytochemical,antioxidant,sensory,andshelf-lifeattributes.Freshbetel leavesweredriedat50°Cforsixhours,grindedinto powder,andaddedtoladduformulations at varying concentrations: 0% (Control), 2.5% (F1), 5% (F2), 7.5% (F3), and 10% (F4). The primary ingredients included chickpea flour, jaggery, ghee, and cardamom.

Nutritional analysis indicated that betel leaf powder is abundant in protein, dietary fiber, minerals, and bioactive compounds. The addition of betel leaf powder significantly enhanced the protein, crude fibre, ash, calcium, and iron levels in the laddus. The F4 formulation demonstratedthehighestnutritionalprofile,featuringprotein(12.8%),crudefiber(6.4%),and increased mineral content.Phytochemicalanalysisrevealed asubstantialrise in totalphenolic andflavonoid levels,leading toimprovedantioxidantactivity. Sensoryevaluation, conducted usinga9-pointhedonicscale,showedthatF4receivedfavorableconsumeracceptancewithan overallscoreof7.6/9.Shelf-lifeassessmentsperformedover60daysunderambientconditions indicated acceptable moisture levels, peroxide values, and microbial quality throughout the

storage period.

The results indicate that be tel leaf powder canbeeffectivelyintegrated intoladdustoenhance theirnutritionalandfunctionalattributes.Theoptimizedformulationcontaining10%betelleaf powderexhibitedsignificantpotentialasashelf-stablefunctionalfoodwithnotableantioxidant advantages.

KEYWORDS: Betel leaf, Piper betel, laddu, functional food, antioxidant activity, nutritional evaluation, phytochemicals, traditional sweet.

INTRODUCTION

About the Study

Thisstudywasconductedtocreateandassessafunctionalfoodproduct,specificallybetelleaf laddu,byintegratingbetelleaf(PiperbetleL.)powderintoaconventionalIndiansweetrecipe. The impetus for this research stemmed from the increasing interest in the use of medicinal plants as functional food components and the necessity to innovate products that merge traditional wisdom with contemporary nutritional needs. Betel leaf, a medicinal plant of cultural importance that is extensively utilized inAyurveda and traditional medicine, exhibits exceptional nutritional and phytochemical characteristics; however, its use in food product development is stilllimited. Consequently, the exploration of incorporating betelleaf powder into laddu was undertaken as a means to improve nutritional value, enhance antioxidant properties, and increase consumer acceptance, while also offering a healthier alternative to traditional methods of betel leaf consumption.

Theresultsofthisresearchindicatethatbetelleafpowderservesasasignificantsourceofvital nutrients, minerals, and bioactive substances. Its abundant presence of phenolic compounds, flavonoids,andnaturalantioxidantsunderscoresitspotentialasafunctionalingredientthatcan lead to enhanced health benefits. The addition of betel leaf powder to laddu recipes markedly improved the nutritional quality of the product by boosting dietary fiber, mineral levels, and antioxidant properties. These enhancements suggest that betel leaf can successfully augment traditional foods, elevating them to nutritionally advanced products.

The creation of various formulations with differing concentrations of betel leaf powder facilitated the evaluation of its impact on product quality. The findings indicated that higher amounts of betel leaf powder positively influenced nutritional and antioxidant properties.

However, elevated concentrations also impacted certain physical and sensory characteristics, including color, texture, aroma, and flavor. Although a darker hue and a slight increase in hardness were noted with greater levels of incorporation, the formulations stayed within acceptable parameters. This study underscored the necessity of finding a balance between improved functional attributes and consumer acceptability in the development of functional food products.

Sensoryevaluationwasessentialindeterminingthemostpreferredformulation.
The panelists typically valued the distinctive flavor and aroma provided by betel leaf when used in moderate amounts. The optimized formulation received positive sensory ratings for appearance,texture,flavor,taste,andoverallacceptability,demonstratingthatbetelleafcanbe effectively integrated into traditional sweets without detracting from consumer preference. Theseresultsendorsethepracticalityofincorporatingbetelleafpowderintovalue-addedfood products and imply that consumers are open to functional foods sourced from traditional medicinal plants.

Theantioxidantevaluationsfurthervalidatedthefunctionalcapabilitiesofbetelleafladdu.The elevated levels of phenolic and flavonoid compounds were correlated with improved free radical scavenging activity and reducing power. These antioxidant characteristics may play a role in safeguarding against oxidative stress, which is associated with the onset of numerous chronic illnesses, such as cardiovascular diseases, diabetes, cancer, and neurodegenerative disorders.

Asaresult,theconsistent intakeoffoodsenriched withbetel leaf may provide healthbenefits that extend beyond mere nutritional value. The assessment of the shelf-life for the optimized formulation revealed that it exhibited satisfactory stability when stored under ambient conditions. Throughout the storage duration, the product preserved acceptable levels of moisturecontent,microbialquality,andsensoryattributes,therebyconfirmingitsviabilityfor commercialproductionanddistribution.Theproduct'sstabilityindicatesthatbetelleafpowder canbeintegratedintotraditionalfoodsystems withoutnotablycompromisingstoragequality, provided that suitable processing and packaging techniques are utilized.

The research underscores the wider importance of incorporating indigenous medicinal plants into the development of food products. Betel leaf has been acknowledged for its healing properties for a long time, yet its application has largely been confined to traditionaluses. By

transforming betel leaf into a functional food component, this study creates a chance to safeguardtraditionalknowledgewhileencouraginghealthiereatingpractices.Additionally,the creationofbetelleafladdupresentsadifferentmethodofconsumptionthatmitigatesthehealth riskslinkedtoarecanut-infusedpaanpreparations,thusenhancingtheadvantagesofbetelleaf whilereducingpossibleadverseeffects.Fromapublichealthstandpoint,betelleafladducould actas apracticaland culturally relevant meansofprovidingvitalnutrientsandantioxidantsto various demographic groups.

This product has the potential to help mitigate nutritional deficiencies, especially concerning iron,calcium,andantioxidantconsumption.Integratingitintocommunitynutritionprograms, school meal initiatives, and health promotion efforts may bolster endeavors focused on enhancing dietary quality and overall health. From an economic perspective, enhancing the value of betel leaves through food processing can generate new market opportunities for farmers, entrepreneurs, and small-scale food industries.

The commercialization of products derived from betel leaves has the potential to increase the economic worth of this traditional crop while promoting sustainable farming practices.Moreover,thecreationoffunctionalfoodsthatutilizelocallysourcedmaterialsisin line with contemporary trends in health-focused consumer markets and contributes to the development of rural livelihoods.

MATERIALS AND METHODS

Phase1:RawMaterialPreparationand Characterization

- Procurementoffreshbetel leaves(Banglavariety)
- Preparationofbetelleafpowder(washing,drying, grinding)
- Proximate,mineral,phytochemical,andantioxidantcharacterizationofbetelleaf Powder

Phase2:LadduFormulationandProcessing

- Developmentoffiveformulationswithvaryingbetelleafpowderconcentrations (0%, 2.5%, 5.0%, 7.5%, 10.0%)
- Standardizationofprocessingparameters(roastingtemperature,time,shaping)

Phase3:ProductEvaluation

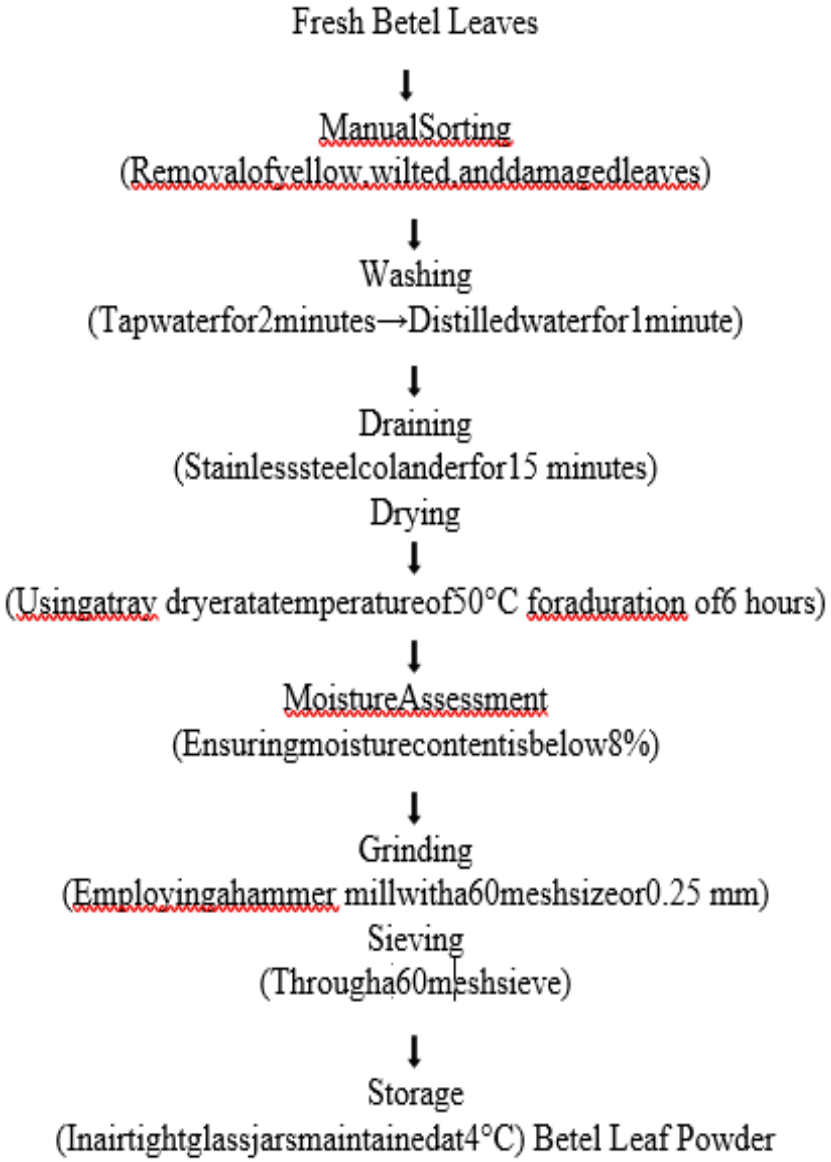
- Proximatecompositionanalysis
- Mineralcontent analysis

- Phytochemicalandantioxidantanalysis
- Physicalproperties(weight,diameter,thickness,spreadratio)
- Textureprofileanalysis(hardness,cohesiveness,springiness)
- Coloranalysis(L,a,b*)
- Sensoryevaluation(9-pointhedonicscale, n=50)

Phase4:Shelf-LifeStudies

- Storageatambientconditions (25±2°C, 65±5%RH) for60 days.
- Monitoringofmoisture,wateractivity,peroxidevalue,andmicrobialcountat15-day intervals.

PROCESS FLOW CHART OF BETELLEAF POWDER



LADDUPROCESSING

Step1: Roasting

- Ghee(25g)wasmeltedinaheavy-bottomedstainlesssteelpanoverlowflame(100120°C)
- Chickpeaflourandbetelleafpowderwereadded
- Themixturewasroastedfor15minuteswithcontinuousstirringusingawooden Spatula.
- Roastingcontinueduntilthemixtureturnedgoldenbrownandemittedanutty,Aromatic smell

Step2: JaggerySyrup Preparation

- Jaggery(30g)andwater(15mL)werecombinedinaseparatepan
- HeatedovermediumflameuntilthejaggerydissolvedcompletelySyrupwasheatedto 110-115°C (soft ball stage: a drop of syrup forms a soft ball When dropped in cold water)Syrup was immediately removed from heat to prevent crystallization

Step3: Mixing

- Roastedflourmixturewastransferredtoastainlesssteelmixing bowl.
- HotjaggerysyrupwasaddedgraduallywhilemixingCardamompowderwas added.
- Themixturewasmixedvigorouslyfor2-3minutesuntilhomogeneousandpliable

Step4: Shaping

- The mixture was allowed to cool to approximately 45°C (warm to touch) Portionsof 20g were weighed using a digital balance.
- Each portion was rolled between the palms to form a smooth, spherical laddu. Target diameter: 3.5-4.0 cm

Step5: Final Coolingand Packaging

- Ladduswereplacedonstainlesssteelwirecooling racks
- Cooledatroomtemperature(25°C)for60 minutes
- Packedinairtightfood-gradepolypropylenecontainers**Yield:**
- Per100gflourbase:approximately5laddus(20geach) Totalladdusper formulation: 125 (2.5 kg total product).

PROXIMATEANALYSIS

- AllanalysiswereperformedintriplicateusingAOAC methods.

MoistureContent(AOAC925.10)

- Clean, dry porcelain crucibles wereheated at105°C for 1 hour, cooled in Desiccator, and weighed (W1)
- Approximately5gofsamplewasweighedintothecrucible (W2)

- Cruciblewas placedinhotairovenat105°Cfor3hours
- Crucible was transferred to desiccator, cooled (30 min), and weighed (W3) Process repeated until constant weight (±0.001g).

ProteinContent(AOAC920.87)–KjeldahlMethod

- Approximately 1 g of samplewas digested with 25mLconcentrated $H_2SO_4$and 10 G catalyst (K_2SO_4:$CuSO_4$, 10:1) at 420°C for 2 hours
- Digestwasdistilledwith50mL 40%NaOHinto 50mL 4%boricacidcontaining Mixed indicator
- Distillatewastitratedwith0.1NHCluntilcolorchangedfromgreentopink.

FatContent(AOAC920.85)–SoxhletMethod

- Approximately5gofsamplewasplacedinextractionthimble
- Extractionflaskwasweighed(W1)
- 150mLpetroleumether(bp40-60°C)was added
- Extractionwascarriedoutfor6hours(minimum6cycles/hour)
- Solventwasevaporated;flaskwithextractedfatwasdriedat105°Cfor30min
- Flaskwascooledandweighed(W2)**MineralAnalysis**
- Calcium(Ca):317.933nm
- Iron(Fe):238.204 nm
- Magnesium (Mg): 285.213 nm Potassium (K): 766.490 nm Zinc(Zn):213.857 nm.

PhytochemicalAnalysis

SampleExtractionforPhytochemicalAnalysis

- 1gofsamplewas extractedwith10mLof80%methanol
- Sonicationfor30minat40°C
- Centrifugationat5000 rpmfor10 min
- Supernatant collectedandstoredat-20°Cuntilanalysis

RESULTS

Table1 Proximate composition of Betel Leaf Powder.

Parameter	Value(%)	Range
Moisture	8.2	7.8-8.6
Protein	14.2	13.7-14.7
Fat	8.6	8.2-9.0
Carbohydrate	52.4	51.2-53.6
Crude fibre	9.8	9.2-10.4
Ash	8.6	8.3-8.9
Energy(kcal/100gm)	352	345-359

Table-2 Mineral Composition of Betel Leaf Powder.

Mineral	(Value mg/100g)	RDAContribution(per10gpowder)
Calcium(Ca)	425	42.5% (adult)
Iron (Fe)	18.6	100%(adultwoman)
Magnesium(Mg)	165	41% (adult)
Potassium(K)	820	16% (adult)
Zinc(Zn)	3.2	29%(adult)

Table-3 Phytochemical Content of Betel Leaf Powder.

Parameter	Value
TotalPhenolicContent(TPC)	285=8mgGAE/g
Totalflavonoidcontent(TFC)	112=5mgQE/g
TanninContent	58 = 3 mg/100g

DISCUSSION

The current research effectively created and assessed a functional laddu enhanced with betel leaf powder (BLP), showcasing its promise as a nutritious and health-enhancing food item.Among the various formulations evaluated, the laddu with 10% betel leaf powder (F4) was identified as the most appropriate formulation, considering its nutritional profile, antioxidant characteristics, sensory appeal, and storage longevity.This study highlights the potential of BLP-enriched laddu as a beneficial addition to the diet.

The addition of betel leaf powder has notably enhanced the nutritional profile of the laddus. Theproteinlevelrosefrom10.5%inthecontrolsampleto12.8%informulationF4,whilethe crude fiber content increased from 2.2% to 6.4%. This increase in fiber may lead to better digestivehealth,improvedglycemiccontrol,andgreaterfeelingsoffullness.Concurrently,the levels of fatand carbohydrates decreased, leading to areduced energy valuein comparison to thecontrolformulation.Thesemodifications suggestthatbetelleaf powder can beeffectively utilized to create healthier versions of traditional sweets without sacrificing their nutritional benefits.

The mineral composition of the developed laddu has been notably enhanced. The levels of calcium, iron, and magnesium rose in proportion to the amount of betel leaf powder used. Consumingtwoladdus(40g)fromtheoptimizedformulationdeliverssignificantquantitiesof these vital minerals, aiding in meeting the Recommended Dietary Allowance (RDA) and promotingbonehealth,hemoglobinproduction,andmetabolicprocesses.Theelevatedmineral levels further underscore the promise of betel leaf as a functional food component.

Phytochemical analysis indicated that betel leaf powder is abundant in bioactive compounds, especially phenolics and flavonoids.The optimized formulation demonstrated a significant

increase in total phenolic content and antioxidant activity when compared to the control. ThedecreaseinIC50values suggestedamorepotentfreeradicalscavengingactivity,thereby confirmingthattheincorporationofbetelleafpowderimprovedtheantioxidantcapacityofthe product.These antioxidant characteristics are primarily linked to compounds like eugenol, hydroxychavicol, and several flavonoids found in betel leaf.

Physical and sensory assessments revealed that the addition of betel leaf powder enhanced hardnessandresultedinadeepergreenhue;however,theoverallacceptabilityoftheoptimized formulationstayedwithinanacceptablerange.Panelistsnotedthedistinctivearomaandflavor linkedtobetelleaf,suggestingthatconsumersarereceptivetotheproduct.Theoverallsensory score of F4 surpassed the minimum requirement for functional food products, indicating that the nutritional improvements did not negatively impact product acceptability.

Shelf-life investigations carried out under normal storage conditions revealed that the optimized laddu maintained microbiologicalsafety and chemicalstability for aduration of up to 60 days..The moisture content, peroxide value, and microbial counts stayed within permissiblelimitsduringtheentirestorageperiod.Nevertheless,agradualriseinwateractivity was noted, indicating that extending storage beyond 60 days might necessitate enhanced packaging or preservation methods.

CONCLUSION

The research effectively created a laddu enriched with betel leaf (F4: 10% betel leaf powder) that exhibits significantly improved nutritional quality, including increased levels of protein, fiber,minerals,andantioxidantactivity,alongsideacceptablesensoryattributes(7.1/9.0).The betel leaf laddushowspromise asafunctionalfoodaimedatenhancing mineralconsumption, especially iron and calcium, while also offering antioxidant advantages.

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