TECHNO-ECONOMIC AND QUALITY EVALUATION OF PESTICIDE-FREE CHILLI (CAPSICUM SPP.) CULTIVATION AND VALUE ADDITION UNDER WOMEN-LED KUDUMBASHREE MODEL IN KERALA, INDIA

[1]Rani R. Nair, [2]Thomson K. Alex, [3]Athuljith A. J., [4]Adhila S.
[1]Associate Professor, [2]Assistant Professor, [3]Senior Information analyst, [4] Assistant Director
[1]Post Graduate and Research Department of Chemistry, Bishop Abraham Memorial College, Thuruthicad, Pathanamthitta, Kerala, India-689597.
[2]Post Graduate Department of Economics, Bishop Abraham Memorial College, Thuruthicad, Pathanamthitta, Kerala, India-689597.
[3]Health intelligence team, Public Health Department, NHS Lanarkshire, Scotland.
[4]Department of Agriculture, Deputed as District Mission Coordinator, State poverty Eradication Mission, Government of Kerala

ABSTRACT

Pesticide residues in commercial chilli production pose significant health and environmental concerns. This study evaluates the “Chilli Village” (Mulak Graamam in malayalam) model implemented in Pathanamthitta District under the Kudumbashree Mission, focusing on pesticide-free chilli cultivation and value addition. The study assesses cultivation practices, yield performance, quality parameters, and economic viability on 25 cents of land managed by women’s Joint Liability Groups (JLGs). Results indicate that raw chilli cultivation yields higher profits compared to chilli powder production, though value addition offers advantages in shelf life and branding. The model demonstrates strong potential for sustainable agriculture and women-led rural entrepreneurship.

KEYWORDS

Organic farming, chilli cultivation, value addition, fertigation, integrated pest management, mulching, quality analysis

I. INTRODUCTION

Chilli (*Capsicum spp.*) is an economically important spice crop widely cultivated in India and other tropical regions. Conventional cultivation practices involve repeated application of synthetic pesticides, which often result in pesticide residues in the final produce and pose risks to human health and the environment[1].
Sustainable agricultural approaches such as organic farming and integrated pest management (IPM) have gained importance in recent years due to their role in improving soil health, reducing environmental pollution, and enhancing food safety[2, 3].
The “Chilli Village” (Mulak Gramam) initiative under the Kudumbashree Mission promotes pesticide-free chilli cultivation through women-led Joint Liability Groups (JLGs). This model integrates ecological pest control, organic nutrient management, and value addition to improve income generation and market sustainability.

II. OBJECTIVES

- To document the package of practices for pesticide-free chilli cultivation
- To compare economic returns from raw chilli and chilli powder
- To evaluate income generation and scalability for women's JLGs
- To assess physicochemical and quality attributes of the produce

III. MATERIALS AND METHODS

3.1 Study Area and Model Design

The study was conducted in Pathanamthitta district, Kerala, under the Kudumbashree Mission, using 25 cents of land managed by a women's JLG.

3.2 Planting Material and Inputs

Hybrid chilli varieties (Sarpan and Armor) were used, with approximately 2,400 seedlings transplanted per 25 cents. Organic fertilizers, lime, and bio-pesticides were applied as per recommended practices.

3.3 Cultivation Practices

Field preparation included lime application to correct soil acidity. Drip irrigation and mulching were adopted for efficient water and nutrient management.
Intercropping with marigold and sunflower was used as a biological pest control strategy, consistent with IPM practices[1]. Weekly application of *Pseudomonas fluorescens* was carried out for disease suppression and plant growth promotion[3].

3.4 Fertigation Method

Fertigation was carried out through the drip irrigation system to ensure precise and efficient delivery of nutrients. Water-soluble organic fertilizers and liquid bio-inputs were applied at regular intervals based on crop growth stages[4].

- Basal application: Organic manure and lime were incorporated into the soil before transplanting.
- Vegetative state (0–30 days): Liquid organic nutrients such as fermented plant extracts and fish amino acid were applied weekly through drip irrigation to promote vegetative growth.
- Flowering and fruiting stage (30–90 days): Nutrient supply was increased with potassium-rich organic formulations and micronutrient solutions to enhance flowering, fruit set, and fruit development.
- Bio-fertigation: Beneficial microbial cultures (e.g., *Pseudomonas fluorescens* and other plant growth-promoting rhizobacteria) were periodically applied through the drip system to improve nutrient uptake and suppress soil-borne pathogens.

Fertigation scheduling was adjusted based on crop performance and environmental conditions to maintain optimal nutrient availability while minimizing losses.

3.5 Crop Growth and Harvesting

Flowering began 23–25 days after transplanting, and harvesting commenced at 47–50 days. Harvesting was conducted at regular intervals over two months, ensuring optimal yield and quality[5].

3.6 Physicochemical Analysis

Physicochemical analysis of fresh chilli and processed chilli powder was carried out using standard analytical methods[6, 7]..

- Moisture content (%) was determined by oven-drying samples at 105°C until constant weight[8].
- pH was measured using a calibrated digital pH meter in an aqueous extract of the sample.
- Samples were analyzed for common pesticide residues using chromatographic techniques[9].

- Capsaicin content (%) was estimated using spectrophotometric/high-performance liquid chromatography (HPLC) methods after solvent extraction.
- Oleoresin content (%) in chilli powder was determined by solvent extraction using acetone or hexane and expressed on a dry weight basis.
- Ash content (%) was measured by incineration in a muffle furnace at 550°C to determine total mineral content.

All analyses were performed in triplicate, and results were expressed as mean values.

IV. RESULTS AND DISCUSSION

4.1 Yield Performance

The yield ranged from 2,000 to 2,500 kg of raw chilli per crop cycle, with a conversion ratio of 6.5:1 for chilli powder production. These results are comparable to reported yields under improved organic cultivation systems.

Raw chilli yield	2,000–2,500 kg per cycle
Conversion ratio	5.5 kg fresh chilli → 1 kg powder
Powder yield	307–384 kg

4.2 Economic Analysis[10]

A. Benefit–Cost Ratio (BCR)

The Benefit–Cost Ratio was calculated using:

$$BCR = \frac{Gross\ Revenue}{Total\ Cost}$$

Raw Chilli Cultivation

Cycle	Gross Revenue	Total Cost	BCR
Cycle 1	₹1,00,000 – ₹1,25,000	₹60,000	1.67 – 2.08
Cycle 2	₹1,00,000 – ₹1,25,000	₹15,000	6.67 – 8.33
Source: Primary Data			

The BCR values above 1 indicate strong economic feasibility. The exceptionally high BCR during the second cycle shows the long-term profitability of the model once initial infrastructure is established.

Chilli Powder Production

Cycle	Gross Revenue	Total Cost	BCR
Cycle 1	₹2,30,250 – ₹2,88,000	₹2,01,500 – ₹2,36,500	1.14 – 1.22
Cycle 2	₹2,30,250 – ₹2,88,000	₹1,56,500 – ₹1,91,500	1.20 – 1.50
Source: Primary Data			

Although the BCR of value-added chilli powder is comparatively lower due to raw material and processing expenses, the enterprise offers advantages such as market diversification, shelf-life extension, branding opportunities, and premium pricing potential.

B. Net Return per Rupee Invested

$$Net\ Return\ per\ Rupee = \frac{Net\ Profit}{Total\ Cost}$$

Enterprise	Cycle 1	Cycle 2
Raw Chilli	0.67 – 1.08	5.67 – 7.33
Chilli Powder	0.14 – 0.22	0.47 – 0.50
Source: Primary Data		

This indicates that raw chilli cultivation generates substantially higher returns on investment, particularly after the first cycle.

4.3 Quality Assessment

Physicochemical Properties

Parameter	Fresh Chilli	Chilli Powder
Moisture content (%)	78–82	8–10
pH	5.5–6.5	5.0–6.0
Pesticide content	No detectable residues of organophosphates, carbamates, or pyrethroids	
Capsaicin content (%)	0.3–0.8	0.5–1.2
Oleoresin content (%)	—	8–12
Ash content (%)	—	5–7

The analysed samples showed desirable moisture, capsaicin, and oleoresin content, indicating high product quality. Capsaicin content is directly associated with pungency and consumer preference The pesticide-free produce exhibited desirable physicochemical characteristics.
The low moisture content in chilli powder indicates good storage stability, while higher oleoresin and capsaicin values contribute to pungency and color quality.

Microbial Quality

Parameter	Observed Value
Total plate count	$< 10^4$ CFU/g
Yeast and mold count	$< 10^3$ CFU/g
Coliforms	Absent

Microbial load was within acceptable limits, indicating good hygienic practices during processing and confirmed the safety of the pesticide-free produce.

Pesticide Residue Analysis

No detectable pesticide residues of organophosphates, carbamates, or pyrethroids were found, confirming the effectiveness of pesticide-free cultivation practices. Residue levels were also below the maximum residue limits (MRLs) aligning with food safety standards.

Sensory Evaluation

Attribute	Score
Color	8.5
Aroma	8.0
Pungency	8.7
Overall acceptability	8.4

High sensory scores for colour, aroma, and pungency indicate strong consumer acceptability, supporting market potential.

The study demonstrates that pesticide-free chilli cultivation is economically viable on small landholdings. However, value-added chilli powder offers:

- Extended shelf life
- Market differentiation
- Branding opportunities

Biological disease control using *Pseudomonas fluorescens* plays a crucial role in maintaining crop health and yield stability.

V. CONCLUSION

The study demonstrates that pesticide-free chilli cultivation under the Kudumbashree model is both economically viable and environmentally sustainable. Raw chilli marketing provides higher net returns due to lower processing costs. The integration of organic practices, biological pest management, and value addition enhances income while ensuring food safety. The increase in profit during the second cycle is attributed to reduced infrastructure costs (drip irrigation and mulching). The quality assessment confirms that pesticide-free chilli produced under the "Chilli Village" model meets both safety and quality standards. The absence of pesticide residues enhances consumer trust, while favorable physicochemical and sensory properties improve marketability. These findings support the potential for premium branding and export opportunities.

VI. RECOMMENDATIONS

- Develop certified branding for pesticide-free chilli products
- Establish solar drying units for cost-effective processing
- Provide training in quality control and packaging
- Scale up the model to other regions

VII. Acknowledgement

The authors acknowledge the support of Kudumbashree Mission and Pathanamthitta District Panchayat for implementing the project.

REFERENCES

1. Pandey, R., Chaturvedi, A.K., Chaudhary, R.P. and Prasad, R. 2017. Integrated pest management strategies in chilli cultivation. *Crop Protection*, 145, 105599.
2. Aulakh, C.S., Sharma, S., Thakur, M. and Kaur, P. 2022. A review of the influences of organic farming on soil quality, crop productivity and produce quality. *Journal of Plant Nutrition*, 45(12), 1–22.
3. a. Reddy, P. P. **2017.** Agro-ecological Approaches to Pest Management for Sustainable Agriculture. Springer. b. Reddy, P. P. 2016. Sustainable Crop Protection under Protected Cultivation. Springer. c. Reddy, P.P. 2014. *Biointensive Integrated Pest Management in Horticultural Ecosystems.* Springer
4. Mariyappillai, A., Arumugam, G. and Singh, D. 2022. Aerobic rice (*Oryza sativa*) cultivation under drip irrigation and fertigation system. *Indian Journal of Agronomy*, 67(1), 1–5.
5. Kumar, S., & Sharma, A. 2021. Advances in organic vegetable production and pest management. *Scientia Horticulturae*, 289, 110455.
6. Datta, S. 2016. Growth, yield and important quality attributes chilli (*Capsicum* sp.) genotypes under the Sub Himalayan tracts of West Bengal. Indian Journal of Horticulture, 73(1), 39–45.
7. Srinivasan, K. 2020. Capsaicin and its biological activities. *Critical Reviews in Food Science and Nutrition*, 60(9), 1459–1480.
8. AOAC International. 2019. *Official Methods of Analysis of AOAC International* (21st ed.). Gaithersburg, MD, USA: AOAC International.
9. FAO. 2022. *Good Agricultural Practices for Capsicum Production*. Food and Agriculture Organization.
10. George A. Pavelis. 2015. The Benefit-Cost Ratio in Resource Development Planning Published online by Cambridge University Press