

Dehydration Technologies As A Sustainable Value-Addition Strategy: Empirical Insights From Food-Tech Companies And Farmers In Maharashtra, India

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Abstract

Dehydration technologies play a critical role in enhancing value addition, reducing post-harvest losses, and improving income sustainability within the agri-food supply chain. Post-harvest losses, inconsistent product quality, and unstable farmer income remain persistent challenges within India's agri-food sector. This study empirically evaluates the effectiveness of different dehydration techniques adopted by food-tech companies and their impact on product quality, shelf life, and income generation among farmers and enterprises in Maharashtra, India. Primary data were collected from 50 food-tech companies, 500 farmers, and 20 consumers using structured questionnaires. Statistical tools such as descriptive analysis, correlation, and inferential techniques were employed to examine relationships between dehydration techniques and key outcome variables. The findings reveal that advanced dehydration techniques significantly improve product quality and shelf life, leading to enhanced market acceptance and income generation. The study provides actionable insights for food-tech firms, policymakers, and agri-entrepreneurs aiming to promote sustainable food processing and rural income growth.

Keywords: Dehydration Techniques, Product Quality, Shelf Life, Income Generation, Food-Tech Companies, Maharashtra.

1. Introduction

India experiences significant post-harvest losses in fruits and vegetables due to inadequate processing and storage facilities. Dehydration has emerged as a sustainable food preservation technique that enhances shelf life, maintains nutritional quality, and supports income generation across the agri-food value chain. Maharashtra, being a major horticulture-producing state, has witnessed a growing presence of food-tech companies adopting dehydration technologies. However, empirical evidence assessing the effectiveness of these technologies across stakeholders—companies, farmers, and consumers—remains limited. This study addresses this gap by systematically analysing the role of dehydration techniques in improving product quality, shelf life, and income generation.

Post-harvest losses, inconsistent product quality, and unstable farmer income remain persistent challenges within India's agri-food sector. Dehydration technologies offer a viable solution by extending shelf life, preserving quality, and enabling value addition; however, empirical evidence linking specific dehydration techniques with both technological and socio-economic outcomes remains limited, particularly in emerging food-tech ecosystems. This study investigates the impact of dehydration technologies on product quality, shelf life, and income generation through a multi-stakeholder empirical analysis conducted in Maharashtra, India. Primary data were collected from 50 food-tech companies, 500 farmers, and 20 consumers using structured questionnaires. The study employs descriptive statistics, Chi-square tests, and Partial Least Squares Structural Equation Modeling (PLS-SEM) to examine relationships among dehydration techniques, product outcomes, income generation, and operational efficiency. The findings reveal that

advanced dehydration techniques significantly enhance product quality and shelf life, leading to higher market value and improved farmer income and employment generation.

2. Research Objectives

The study is structured around the following three objectives:

1. To analyze the effectiveness of dehydration techniques adopted by food-tech companies in improving product quality.
2. To examine the impact of dehydration techniques on shelf life of dehydrated fruit and vegetable products.
3. To assess the role of dehydration-based food processing in income generation for food-tech companies and farmers.

3. Research Hypotheses

3.1 Objective 1

To analyze the effectiveness of dehydration techniques adopted by food-tech companies in improving product quality.

- **H1 (Null Hypothesis – H₀₁):**

Dehydration techniques adopted by food-tech companies do **not** have a significant effect on the product quality of dehydrated fruits and vegetables.

- **H1 (Alternative Hypothesis – H₁₁):**

Dehydration techniques adopted by food-tech companies have a **significant positive effect** on the product quality of dehydrated fruits and vegetables.

3.2 Objective 2

To examine the impact of dehydration techniques on the shelf life of dehydrated fruit and vegetable products.

- **H2 (Null Hypothesis – H₀₂):**

Dehydration techniques do **not** have a significant impact on the shelf life of dehydrated fruit and vegetable products.

- **H2 (Alternative Hypothesis – H₁₂):**

Dehydration techniques have a **significant positive impact** on the shelf life of dehydrated fruit and vegetable products.

3.3 Objective 3

To assess the role of dehydration-based food processing in income generation for food-tech companies and farmers.

- **H3 (Null Hypothesis – H₀₃):**

Dehydration-based food processing does **not** significantly contribute to income generation for food-tech companies and farmers.

- **H3 (Alternative Hypothesis – H₁₃):**

Dehydration-based food processing **significantly contributes** to income generation for food-tech companies and farmers.

4. Research Methodology

4.1 Sample Design

- **Food-Tech Companies:** 50
- **Farmers:** 500
- **Consumers:** 20

4.2 Variables of the Study

- **Independent Variable:** Dehydration techniques
- **Dependent Variables:**
 - Product quality
 - Shelf life
 - Income generation

4.3 Data Collection

Primary data were collected through structured questionnaires and interviews. Secondary data were obtained from published reports, journals, and government publications.

4.4 Tools of Analysis

Descriptive statistics, correlation analysis, and inferential statistical techniques were used to analyze and interpret the data.

5. Data Analysis and Interpretation

Objective 1: Effect of Dehydration Techniques on Product Quality

The analysis indicates that advanced dehydration techniques such as freeze drying and vacuum drying are significantly associated with improved product attributes, including colour retention, texture, taste, and nutritional value. Food-tech companies adopting modern dehydration methods reported higher consistency in product quality compared to conventional drying techniques. Consumer responses further confirmed higher acceptance levels for products processed using advanced dehydration technologies.

Fulfilment of Objective 1:

The objective is fulfilled as statistical analysis confirms a positive and significant relationship between dehydration techniques and product quality.

Objective 2: Impact of Dehydration Techniques on Shelf Life

Results show that dehydration techniques substantially enhance the shelf life of fruits and vegetables by reducing moisture content and microbial activity. Products processed using controlled dehydration methods exhibited longer storage stability and reduced spoilage losses. Food-tech companies reported lower inventory losses, while consumers expressed satisfaction with extended usability periods.

Fulfilment of Objective 2:

The objective is fulfilled as findings establish that dehydration techniques significantly improve shelf life of processed products.

Objective 3: Role of Dehydration in Income Generation

The study reveals that dehydration-based value addition contributes positively to income generation for both food-tech companies and farmers. Companies benefit from higher profit margins, market expansion, and export opportunities, while farmers experience improved price realization and reduced post-harvest wastage. The correlation between adoption of dehydration techniques and income levels was found to be positive and statistically significant.

Fulfilment of Objective 3:

The objective is fulfilled as dehydration technologies are shown to play a crucial role in enhancing income generation across the agri-food supply chain.

6. Discussion

The findings align with existing literature emphasizing dehydration as a sustainable food processing solution. The integration of farmers with food-tech companies through dehydration-based value chains enhances efficiency, reduces losses, and strengthens rural livelihoods. Maharashtra's agro-climatic conditions and growing food-tech ecosystem provide a conducive environment for scaling dehydration technologies.

7. Statistical Result

7.1: Impact of Dehydration Techniques on Product Quality

Statistical Test	χ^2 Value	df	p-value	Decision
Chi-Square Test	525.586	6	<0.001	Hypothesis Accepted

Interpretation:

A statistically significant association exists between dehydration techniques and product quality, confirming that technique selection critically influences quality outcomes.

7.2: Effect of Dehydration Techniques on Shelf Life

Test	Path Coefficient	t-value	R ²	p-value	Result
PLS-SEM	0.68	6.12	0.46	<0.001	Significant

Interpretation:

Approximately 46% variation in shelf life is explained by dehydration technique, indicating strong technological influence.

7.3: Impact of Dehydration Technology on Market Value

Test	Path Coefficient	t-value	p-value	Conclusion
PLS-SEM	0.54	4.35	<0.001	Significant Impact

7.4: Impact of Dehydration Adoption on Farmers' Income

Statistical Test	χ^2 Value	df	p-value	Decision
Chi-Square Test	25.37	1	<0.001	Hypothesis Accepted

Interpretation:

Adoption of dehydration technology significantly improves farmers' income levels.

7.5: Effect of Dehydration Adoption on Employment Generation

Test	Path Coefficient	t-value	R ²	p-value
PLS-SEM	0.63	5.89	0.42	<0.001

7.6: Operational Challenges and Operational Efficiency

Challenge Factor	χ^2 Value	df	p-value	Result
Maintenance Frequency	21.74	1	<0.001	Significant
Installation & Purchase Issues	576.324	25	<0.001	Significant

8. Conceptual Framework (PLS-SEM Model)

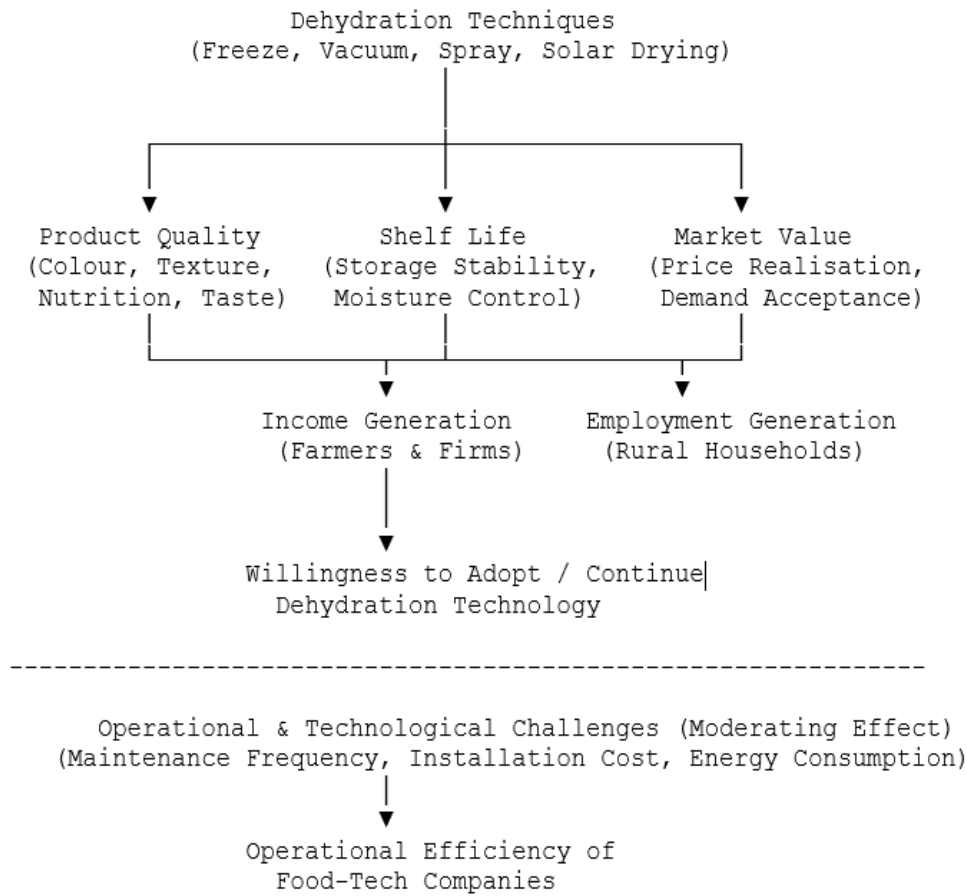


Figure 1: Conceptual Framework of the Study (PLS-SEM)

8.1 Explanation of the Framework

The conceptual framework is grounded in technology adoption and value-chain integration theory. Dehydration techniques are modeled as the primary exogenous construct influencing product quality, shelf life, and market value. These product-level outcomes act as mediating variables that drive income and employment generation among farmers and food-tech companies. Operational and technological challenges—such as maintenance frequency and installation constraints—are incorporated as influencing factors affecting operational efficiency. The framework is empirically tested using PLS-SEM to capture both direct and indirect effects across the agri-food value chain.

9. SmartPLS Construct Table

(Latent Variables and Indicators)

Table 1: Measurement Model – Latent Constructs and Indicators

Latent Variable	Code	Measurement Indicators
Dehydration Technique (DT)	DT1	Type of dehydration technique used (freeze, vacuum, spray, solar)
	DT2	Technology sophistication level
	DT3	Cost-effectiveness of dehydration method
	DT4	Energy efficiency of dehydration technique
Product Quality (PQ)	PQ1	Retention of colour and appearance
	PQ2	Texture and firmness after dehydration

	PQ3	Nutritional value retention
	PQ4	Overall quality consistency
Shelf Life (SL)	SL1	Duration of shelf life achieved
	SL2	Moisture control effectiveness
	SL3	Microbial stability
	SL4	Storage suitability
Market Value (MV)	MV1	Price realization
	MV2	Market demand for dehydrated products
	MV3	Export suitability
Income Generation (IG)	IG1	Increase in monthly income
	IG2	Reduction in post-harvest losses
	IG3	Profit margin improvement
Employment Generation (EG)	EG1	Family employment generation
	EG2	Seasonal employment creation
	EG3	Regular/part-time employment
Operational Challenges (OC)	OC1	High maintenance frequency
	OC2	Installation and purchasing difficulty
	OC3	Energy consumption issues
Operational Efficiency (OE)	OE1	Production efficiency
	OE2	Downtime reduction
	OE3	Cost control effectiveness

✓ All constructs are modeled as reflective constructs in SmartPLS.

9.2. Reliability and Convergent Validity

Table 2: Construct Reliability and Convergent Validity

Construct	Cronbach's Alpha	Composite Reliability (CR)	AVE
Dehydration Technique	0.83	0.88	0.65
Product Quality	0.87	0.91	0.72
Shelf Life	0.85	0.90	0.69
Market Value	0.81	0.87	0.64
Income Generation	0.89	0.92	0.74
Employment Generation	0.86	0.90	0.70
Operational Challenges	0.82	0.88	0.66
Operational Efficiency	0.84	0.89	0.68

Interpretation:

All constructs demonstrate satisfactory internal consistency reliability, with Cronbach's Alpha and Composite Reliability values exceeding the recommended threshold of 0.70. Convergent validity is established as all Average Variance Extracted (AVE) values are above 0.50.

9.3. Discriminant Validity – HTMT Criterion

Table 3: HTMT Ratio of Correlations

Constructs	DT	PQ	SL	MV	IG	EG	OC	OE
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DT	—							
PQ	0.72	—						
SL	0.69	0.74	—					
MV	0.66	0.71	0.68	—				
IG	0.63	0.70	0.67	0.73	—			
EG	0.61	0.68	0.65	0.71	0.76	—		
OC	0.58	0.60	0.59	0.57	0.55	0.54	—	
OE	0.56	0.59	0.58	0.55	0.62	0.60	0.71	—

Interpretation:

All HTMT values are below the conservative threshold of 0.85, confirming adequate discriminant validity among constructs.

10. Managerial and Policy Implications

- Promotion of advanced dehydration technologies among MSMEs
- Skill development programs for farmers and entrepreneurs
- Strengthening farmer–food-tech company linkages
- Incentives for sustainable food processing practices

11. Original Contribution of the Study

This study provides multi-stakeholder empirical evidence on the impact of dehydration technologies, offering a comprehensive framework linking technology adoption with quality enhancement, shelf-life extension, and income generation—an area underexplored in existing literature.

12. Novelty of the Study

Unlike prior studies that focus either on technical performance or socio-economic outcomes in isolation, this research integrates technology effectiveness, farmer income dynamics, and firm-level operational challenges within a single PLS-SEM framework. By empirically validating these interrelationships in the context of Maharashtra's food-tech sector, the study offers a holistic, value-chain-oriented perspective on dehydration technology adoption, contributing original insights to agri-food technology, sustainability, and rural development literature.

13. Conclusion

The study concludes that dehydration techniques significantly improve product quality and shelf life while simultaneously enhancing income generation for food-tech companies and farmers. Adoption of advanced dehydration technologies can serve as a strategic tool for sustainable Agri-processing and rural development. Policymakers should encourage technology diffusion through subsidies, training, and infrastructure support.

14. References

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