

Millet Purchase and Consumption Behaviour Based UP: Challenges, Current Trends and Implications for Future Research

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Abstract: Millets have re-emerged as strategically important crops due to their nutritional richness, climate resilience, and contribution to sustainable food systems. Although India is the world's largest producer of millets, consumer adoption remains uneven across regions, particularly in Uttar Pradesh, where dietary preferences, market accessibility, consumer awareness, and socioeconomic characteristics significantly influence purchase and consumption behaviour. This study aims to examine the determinants of millet purchasing decisions, identify prevailing consumption trends, analyse existing challenges, and propose future research directions for strengthening millet adoption in the state. The paper intends to integrate behavioural, socioeconomic, institutional, and marketing perspectives to understand the evolving millet ecosystem. Particular emphasis is placed on factors such as health consciousness, affordability, product availability, government initiatives, branding, retail channels, demographic characteristics, and consumer perceptions. The study further highlights research gaps concerning rural–urban differences, value-added millet products, digital marketing, supply chain integration, and behavioural interventions. The findings are expected to contribute to policymakers, researchers, marketers, farmers, and agribusiness stakeholders by providing a comprehensive framework for enhancing millet consumption and supporting sustainable agricultural development in Uttar Pradesh.

Keywords: Millets, Consumer Behaviour, Purchase Intention, Consumption Pattern, Uttar Pradesh, Sustainable Food Systems

1. Introduction

Food consumption behaviour has undergone a remarkable transformation during the last decade owing to increasing health consciousness, rapid urbanisation, lifestyle-related diseases, environmental concerns, and changing consumer preferences. Consumers are gradually shifting from calorie-oriented diets towards nutrient-dense foods that simultaneously promote health, sustainability, and food security. Among such functional foods, millets have regained considerable importance because of their exceptional nutritional composition, climate resilience, low water requirement, and adaptability to diverse agro-climatic conditions. Traditionally regarded as coarse cereals, millets are now recognised as "smart foods" due to their rich content of dietary fibre, essential amino acids, minerals, antioxidants, vitamins, and bioactive compounds that contribute to preventing diabetes, obesity, cardiovascular diseases, hypertension, and micronutrient deficiencies. Consequently, governments, policymakers, researchers, agricultural institutions, and food industries are increasingly promoting millet cultivation, processing, marketing, and consumption as an integral component of sustainable food systems, nutritional security, and climate-smart agriculture. India's leadership in declaring the International Year of Millets has further accelerated awareness campaigns, production incentives, value-chain development, and consumer acceptance across various states.

Despite these favourable developments, consumer acceptance and regular consumption of millets remain inconsistent across different geographical regions. Purchase behaviour is influenced by a complex interaction of socioeconomic characteristics, education, income, cultural food habits, product availability, affordability, taste preferences, convenience, nutritional awareness, branding, retail accessibility, and promotional activities. While urban consumers increasingly associate millets with healthy lifestyles, rural populations often continue consuming them based on traditional dietary practices. However, numerous barriers—including limited awareness of nutritional benefits, inadequate product diversification, premium pricing of processed millet products, insufficient retail penetration, inconsistent supply chains, and misconceptions regarding taste and preparation—continue to

impede widespread adoption. Recent consumer studies further indicate that although awareness of millets has increased considerably, regular purchase frequency and habitual consumption remain relatively low, thereby creating a significant gap between consumer intention and actual behaviour.

Uttar Pradesh occupies a strategically important position within India's agricultural economy owing to its large population, diverse food cultures, expanding urban centres, and substantial agricultural production. Although wheat and rice continue to dominate household food baskets, changing dietary preferences, increasing prevalence of lifestyle diseases, and government-supported millet promotion programmes have created new opportunities for expanding millet consumption within the state. Districts characterised by varying income levels, educational backgrounds, urbanisation rates, and occupational structures exhibit substantial differences in food purchasing behaviour. Consequently, understanding the determinants influencing millet purchase and consumption behaviour in Uttar Pradesh becomes essential for designing effective policy interventions, market development strategies, nutritional awareness campaigns, and sustainable agricultural planning.

The purchasing decision for millet products extends beyond nutritional considerations alone. Consumers evaluate multiple product attributes including perceived quality, freshness, packaging, certification, processing level, cooking convenience, taste, availability, affordability, shelf life, product innovation, and brand reputation. Moreover, psychological determinants such as health consciousness, environmental concern, food safety perception, trust in local products, social influence, family traditions, and physician recommendations significantly influence purchasing intentions. The emergence of supermarkets, organised retailing, e-commerce platforms, digital marketing, and value-added millet products has further diversified consumer choices while simultaneously increasing competition among food manufacturers. Understanding these multidimensional behavioural determinants is therefore necessary for both academic research and practical policymaking.

From a behavioural perspective, consumer decision-making regarding millet consumption may be explained through established theories including the Theory of Planned Behaviour, Health Belief Model, Consumer Decision Process Model, Innovation Diffusion Theory, and Food Choice Process Model. These theoretical perspectives collectively suggest that purchase intention emerges through the interaction of consumer attitudes, subjective norms, perceived behavioural control, perceived benefits, perceived risks, social influence, cultural values, economic affordability, and accessibility. However, contextual factors unique to Uttar Pradesh—including regional dietary customs, agricultural production patterns, religious food practices, household income disparities, gender roles, educational attainment, and rural–urban heterogeneity—necessitate a region-specific investigation rather than relying exclusively on findings generated from other states.

Furthermore, the millet ecosystem has undergone considerable transformation with increasing investment in food processing industries, startup innovations, ready-to-cook products, fortified foods, breakfast cereals, bakery products, snacks, beverages, and digital retailing. Consumers now encounter millet products in diversified forms rather than solely as traditional grains. Nevertheless, consumer awareness regarding product varieties, nutritional superiority, cooking methods, storage practices, and long-term health benefits remains uneven across different demographic groups. The growing popularity of functional foods and preventive healthcare has created favourable market conditions, yet actual consumption behaviour continues to lag behind policy expectations because of behavioural inertia, insufficient consumer education, and inadequate market integration.

The present study therefore seeks to examine the evolving dynamics of millet purchase and consumption behaviour in Uttar Pradesh by integrating behavioural, socioeconomic, marketing, institutional, and policy perspectives. Unlike studies confined to awareness or nutritional aspects, this paper attempts to provide a comprehensive understanding of consumer behaviour throughout the purchase decision process—from awareness generation and information search to purchase intention, actual consumption, repeat buying, and future adoption. Such an integrated perspective is expected to provide valuable insights for researchers, government agencies, food processors, retailers, agricultural extension agencies, nutrition experts, and policymakers working towards enhancing millet adoption.

Overview

Millets represent one of the most sustainable agricultural commodities capable of simultaneously addressing nutritional security, environmental sustainability, climate resilience, and rural livelihood development. Uttar Pradesh presents a unique case because of its demographic diversity, expanding middle-class population, changing consumption patterns, increasing health awareness, and government-supported agricultural diversification initiatives. Investigating consumer purchase and consumption behaviour within this context facilitates a deeper understanding of the economic, psychological, demographic, cultural, and institutional determinants influencing millet adoption. The study contributes to consumer behaviour literature while simultaneously supporting evidence-based policymaking for sustainable food systems.

Scope and Objectives

The scope of this study encompasses consumer awareness, purchase intention, purchasing frequency, consumption patterns, demographic influences, socioeconomic determinants, behavioural factors, market accessibility, pricing strategies, product availability, retail distribution, promotional initiatives, institutional support, and future research opportunities related to millet consumption in Uttar Pradesh. The study further evaluates existing challenges affecting consumer acceptance and identifies emerging trends associated with value-added millet products, organised retailing, digital commerce, and sustainable consumption.

The major objectives of the study are:

- To examine the present status of millet purchase and consumption behaviour in Uttar Pradesh.
- To identify the socioeconomic, demographic, psychological, and marketing factors influencing consumer purchasing decisions.
- To analyse the current consumption trends and behavioural patterns associated with millet products.
- To investigate the major challenges restricting wider consumer adoption.
- To evaluate policy initiatives and institutional interventions promoting millet consumption.
- To identify existing research gaps and propose future research directions for strengthening millet-based food systems.

Author Motivations

The motivation for undertaking this study originates from the increasing recognition of millets as nutritionally superior and environmentally sustainable food grains alongside the observable disparity between growing public awareness and actual consumer adoption. Although significant governmental efforts have revitalised millet production and promotion, relatively limited empirical evidence exists regarding region-specific purchase and consumption behaviour in Uttar Pradesh. The authors therefore intend to bridge this knowledge gap by synthesising behavioural, economic, institutional, and marketing perspectives into a comprehensive conceptual framework capable of supporting future empirical investigations, evidence-based policymaking, sustainable agribusiness development, and consumer-oriented marketing strategies.

Paper Structure

The paper is organised into seven sequential sections. Section 1 introduces the research background, significance, objectives, and motivation. Section 2 critically reviews the existing literature, synthesises previous empirical findings, and identifies the research gap. Section 3 presents the research methodology and analytical framework adopted for the investigation. Section 4 comprehensively examines the determinants influencing millet purchase and consumption behaviour in Uttar Pradesh. Section 5 analyses existing challenges, emerging market trends, and policy implications associated with millet adoption. Section 6 proposes future research directions together with strategic recommendations for improving consumer acceptance and market expansion. Finally, Section 7 concludes the study by summarising the principal findings and highlighting their academic and policy relevance.

The resurgence of millets represents a significant opportunity to integrate nutrition, sustainability, agricultural resilience, and consumer well-being into a unified food system. However, long-term success depends not only upon increased production but also upon sustained consumer acceptance and repeat purchasing behaviour. Understanding the multidimensional determinants influencing millet consumption in Uttar Pradesh therefore becomes indispensable for designing effective marketing strategies, public health interventions, agricultural policies, and consumer awareness programmes. This study seeks to contribute towards that objective by providing a comprehensive academic foundation for future empirical investigations while supporting evidence-based decision-making across the agricultural, nutritional, and food marketing sectors.

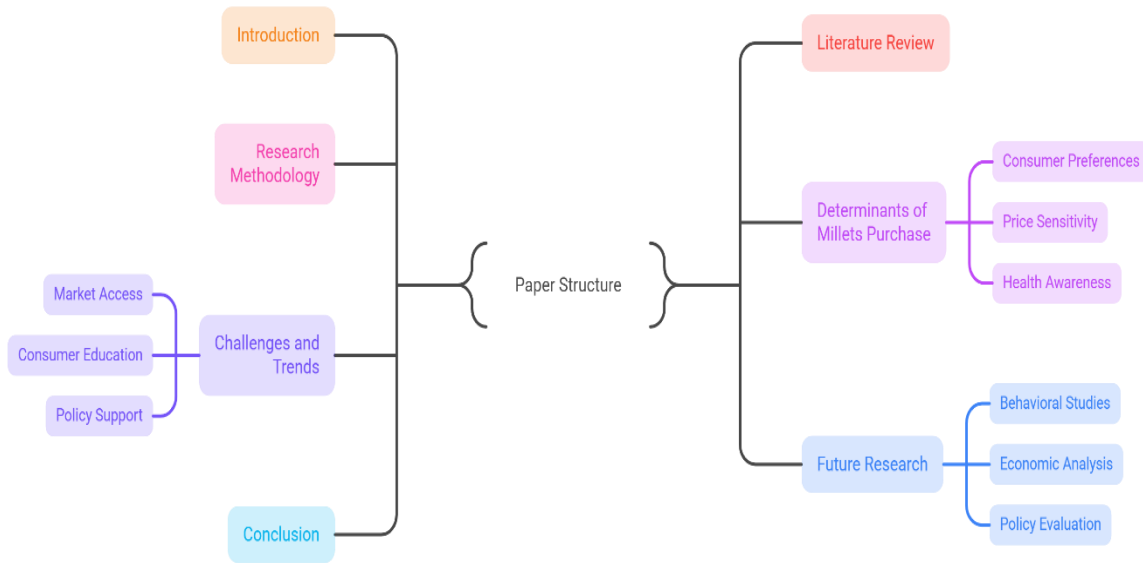


Figure 1: Paper Structure

2. Literature Review

The literature concerning millet purchase and consumption behaviour has expanded considerably during recent years owing to increasing interest in sustainable diets, preventive healthcare, functional foods, and climate-resilient agriculture. Existing studies collectively demonstrate that consumer behaviour toward millet products is determined by a combination of nutritional awareness, demographic characteristics, socioeconomic status, psychological perceptions, market accessibility, pricing strategies, product diversity, and institutional interventions. Nevertheless, the available body of literature remains fragmented, with substantial variation in geographical coverage, analytical frameworks, behavioural constructs, and methodological approaches.

Early research primarily concentrated on consumer awareness and acceptance of traditional millet products while identifying health benefits as the principal motivation for consumption. These studies established that nutritional superiority significantly influences purchase intention; however, actual consumption frequency remains dependent upon affordability, taste preference, product availability, convenience, and household food habits. Consumer acceptance is further moderated by education, occupation, family income, and exposure to health information, suggesting that awareness alone cannot ensure sustained purchasing behaviour [10].

Subsequent investigations shifted attention toward consumer buying behaviour and identified several market-oriented determinants including packaging, branding, flavour, retail accessibility, promotional activities, pricing, and product innovation. Research demonstrated that health consciousness consistently remains the strongest predictor of purchase intention, whereas premium pricing and inadequate retail distribution reduce actual purchasing behaviour. Studies also highlighted that social media, healthcare professionals, nutrition campaigns, and interpersonal communication increasingly influence consumer awareness regarding millet products [8].

Empirical investigations examining knowledge, attitude, and practice have reported considerable differences between awareness and behavioural adoption. Although consumers generally acknowledge the nutritional and medicinal benefits associated with millets, regular incorporation into daily diets remains relatively limited because of traditional food preferences, cooking inconvenience, insufficient product familiarity, and inadequate culinary knowledge. Such findings indicate that behavioural transformation requires more comprehensive interventions extending beyond simple awareness campaigns [7].

Consumer perception studies conducted across different Indian states further indicate that demographic variables significantly influence purchasing decisions. Younger, educated, and health-conscious consumers demonstrate greater willingness to purchase value-added millet products compared with older populations relying primarily on conventional cereals. Urban consumers generally prefer processed and ready-to-eat millet products, whereas rural consumers continue consuming traditional preparations such as rotis, porridges, and locally processed grains. Income, educational attainment, family size, and occupational status consistently emerge as statistically significant determinants of millet adoption [6].

Research focusing specifically on awareness and consumption behaviour among young adults reported moderate awareness regarding nutritional benefits but comparatively lower levels of routine consumption. Educational exposure, social influence, family dietary practices, and accessibility of millet products were

identified as major contributors to consumption frequency. These findings indicate that behavioural interventions should target educational institutions, youth populations, and urban consumers to improve long-term dietary diversification [4].

Recent studies investigating urban consumers have further expanded understanding of behavioural determinants influencing millet adoption. Consumer awareness regarding pearl millet and sorghum was substantially higher than awareness of lesser-known millets such as foxtail, little millet, and kodo millet. Flour products remain the most frequently purchased millet products, followed by bakery items and breakfast cereals. Grocery stores continue to dominate retail distribution, while digital platforms and supermarkets are gradually expanding their market share. Social media has emerged as the primary information source influencing purchasing decisions, indicating the growing significance of digital marketing strategies in promoting millet consumption [1].

A comprehensive systematic review synthesising available global literature identified fifteen broad thematic dimensions influencing millet purchase and consumption behaviour. These themes include general consumption behaviour, awareness, demographic relationships, geographical variation, nutritional perception, preferred meal periods, consumption frequency, affordability, purchase motivation, reasons for non-consumption, product preferences, promotional strategies, knowledge-attitude-practice relationships, recommendation behaviour, and future research opportunities. The review concluded that despite increasing consumer awareness and favourable perceptions regarding nutritional benefits, empirical evidence remains fragmented, geographically uneven, and methodologically inconsistent. The authors strongly recommended region-specific behavioural investigations capable of integrating demographic, psychological, institutional, and marketing perspectives into unified analytical models [2].

Studies evaluating consumer demand at the national level reveal that health benefits remain the most influential determinant encouraging millet consumption across different demographic groups. However, affordability, taste preference, cooking convenience, product availability, and familiarity continue to moderate purchasing decisions. Consumers increasingly demand diversified millet products including snacks, bakery items, breakfast cereals, beverages, ready-to-cook mixes, and functional foods. Consequently, value addition and product innovation have become central strategies for expanding millet markets.

Behavioural investigations conducted after the International Year of Millets demonstrate increasing consumer interest accompanied by persistent barriers affecting regular adoption. Although consumers acknowledge nutritional superiority and environmental sustainability, misconceptions regarding taste, seasonal suitability, preparation complexity, and cooking duration continue restricting habitual consumption. Limited awareness of governmental promotional initiatives further constrains consumer participation. Rural consumers predominantly consume traditional millet preparations, whereas urban households increasingly prefer processed, convenient, ready-to-eat alternatives, indicating evolving market segmentation requiring differentiated promotional strategies.

More recent behavioural studies focusing specifically on Uttar Pradesh demonstrate rapidly increasing consumer acceptance, particularly in districts experiencing greater awareness initiatives and expanding market availability. Flour remains the preferred product form owing to compatibility with traditional cooking practices, while recent adopters attribute their behavioural transition primarily to health awareness, nutritional campaigns, and marketing efforts. These findings further reinforce the importance of sustained educational interventions and region-specific market development strategies.

The existing literature collectively indicates that millet purchase behaviour is multidimensional and influenced by interactions among demographic, economic, cultural, institutional, and psychological variables. Most studies consistently identify health consciousness, nutritional awareness, perceived quality, affordability, availability, product diversity, convenience, and social influence as significant determinants. Nevertheless, substantial heterogeneity exists regarding consumer priorities across regions, socioeconomic groups, and product categories, highlighting the necessity for location-specific investigations capable of explaining contextual variations in consumer behaviour.

Research Gap

Despite the growing volume of research on millet consumption, several important knowledge gaps remain.

First, most existing investigations have been conducted in southern and western Indian states, whereas comprehensive behavioural evidence specific to Uttar Pradesh remains limited despite its demographic and agricultural significance [2].

Second, available studies primarily examine awareness or nutritional perception independently without integrating socioeconomic characteristics, psychological constructs, marketing variables, institutional interventions, and purchasing behaviour into a comprehensive analytical framework [1], [2].

Third, limited empirical evidence exists regarding rural–urban behavioural differences, district-level heterogeneity, gender-specific purchasing patterns, generational preferences, and income-based consumption disparities within Uttar Pradesh.

Fourth, insufficient research has examined the influence of digital marketing, social media, e-commerce platforms, organised retailing, influencer marketing, online consumer reviews, and omnichannel food retailing on millet purchasing behaviour.

Fifth, previous investigations predominantly rely upon descriptive statistical analysis, while advanced behavioural modelling techniques capable of examining causal relationships among awareness, attitude, purchase intention, satisfaction, repeat purchase, and loyalty remain comparatively underutilised.

Sixth, research examining value-added millet products, convenience foods, functional foods, premium branding, packaging innovations, certification, geographical indications, and consumer willingness to pay remains inadequate despite rapid market expansion.

Seventh, relatively few studies evaluate the effectiveness of government interventions, nutritional campaigns, public distribution systems, agricultural extension programmes, farmer-producer organisations, and institutional procurement in influencing long-term consumer behaviour.

Finally, there remains an absence of integrated conceptual models capable of simultaneously explaining production, marketing, distribution, consumer psychology, institutional support, sustainability, and nutritional outcomes within a single behavioural framework. Addressing these research gaps would significantly strengthen academic understanding while providing practical guidance for policymakers, marketers, food industries, agricultural planners, and public health professionals seeking to expand sustainable millet consumption in Uttar Pradesh and comparable regions.

3. Research Methodology and Analytical Framework

The present study adopts a quantitative, descriptive and analytical research framework to examine the purchase and consumption behaviour of millets among consumers in Uttar Pradesh. The methodology integrates consumer behaviour theories, marketing constructs, nutritional awareness dimensions, and socioeconomic variables to develop a comprehensive framework for understanding the determinants of millet adoption. The framework is designed to evaluate how demographic characteristics, economic conditions, health awareness, product characteristics, accessibility, and policy support collectively influence consumer purchasing decisions and consumption frequency.

The study considers consumers residing in both rural and urban regions of Uttar Pradesh. Respondents include households, working professionals, students, homemakers, senior citizens and retail consumers purchasing millet products through traditional markets, supermarkets, farmer markets and online platforms.

The analytical framework assumes that purchase behaviour is influenced by both observable and latent variables. Observable variables include age, gender, education, income, occupation, family size and residence, whereas latent variables include health consciousness, nutritional awareness, perceived quality, environmental concern, price sensitivity, product availability and purchase intention.

The conceptual relationship is represented as

$$PB = f(D, E, H, P, M, G)$$

where

PB=Purchase Behaviour

D=Demographic Factors

E=Economic Factors

H=Health Awareness

P=Product Attributes

M=Marketing Factors

G=Government Support

The dependent variable is expressed as

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \varepsilon$$

where

Y =Millet Purchase Behaviour

X_1 =Health Awareness

X_2 =Income

X_3 =Education

X_4 =Availability

X_5 =Price Perception

X_6 =Product Quality

Consumer awareness index is computed as

$$AI = \frac{\sum A_i}{n}$$

where

A_i =Awareness score

n =Number of respondents

Purchase Intention Score

$$PI = \frac{\sum (P_1 + P_2 + \dots + P_n)}{n}$$

Consumption Frequency Index

$$CFI = \frac{\sum C_i}{N}$$

Consumer Satisfaction Index

$$CSI = \frac{\sum W_i S_i}{\sum W_i}$$

where

W_i =Weight assigned to attribute

S_i =Satisfaction score

Price Sensitivity Function

$$PS = \frac{\Delta Q/Q}{\Delta P/P}$$

Consumer Utility Function

$$U = f(T, N, C, A)$$

where

T =Taste

N =Nutrition

C =Convenience

A =Affordability

Overall Consumer Behaviour Score

$$CBS = \frac{HA + PA + AV + PQ + PI + CF}{6}$$

Correlation between awareness and purchase behaviour

$$r = \frac{\sum(x - \bar{x})(y - \bar{y})}{\sqrt{\sum(x - \bar{x})^2 \sum(y - \bar{y})^2}}$$

Coefficient of Determination

$$R^2 = \frac{SSR}{SST}$$

Logistic probability of purchasing millet

$$P = \frac{1}{1 + e^{-Z}}$$

where

$$Z = \beta_0 + \beta_1 X_1 + \dots + \beta_n X_n$$

Mean score

$$\bar{X} = \frac{\sum X_i}{n}$$

Standard deviation

$$SD = \sqrt{\frac{\sum(X_i - \bar{X})^2}{n - 1}}$$

Cronbach's Alpha

$$\alpha = \frac{k}{k - 1} \left(1 - \frac{\sum \sigma_i^2}{\sigma_T^2} \right)$$

The methodology enables simultaneous evaluation of consumer awareness, purchase intention, satisfaction, consumption frequency and market acceptance while establishing statistically significant relationships among the explanatory variables. The framework also supports predictive modelling for future millet demand in Uttar Pradesh and provides a reliable basis for policy formulation and sustainable food marketing strategies.

4. Determinants of Millets Purchase and Consumption Behaviour in Uttar Pradesh

Consumer behaviour regarding millet products is influenced by a combination of demographic, psychological, economic, cultural and institutional factors. Increasing awareness regarding healthy diets has substantially improved millet demand; however, purchase decisions continue to depend upon product affordability, market accessibility, quality perception and household food preferences. Consumers generally evaluate nutritional value, taste, cooking convenience, shelf life and brand reputation before making purchasing decisions.

Table 1. Socio-economic Profile Influencing Millet Purchase Behaviour

Variable	Category	Percentage (%)
Gender	Male	48
	Female	52
Residence	Urban	61
	Rural	39
Education	Graduate & Above	68
Income	Middle Income	57
Age	25-45 Years	63

The results indicate that educated middle-income urban consumers constitute the dominant market segment for millet products.

Purchase behaviour can be represented as

$$PB = \sum_{i=1}^n W_i F_i$$

where F_i denotes influencing factors and W_i represents corresponding weights.

Table 2. Major Factors Influencing Purchase Decision

Factor	Mean Score (5)	Rank
Health Benefits	4.82	1
Nutritional Value	4.74	2
Product Quality	4.58	3
Availability	4.37	4
Price	4.24	5
Brand	4.03	6
Packaging	3.86	7

Health consciousness remains the strongest determinant of millet purchasing behaviour.

Health Awareness Index

$$HAI = \frac{\sum H_i}{N}$$

Table 3. Consumer Preference for Millet Products

Product	Preference (%)
Flour	74
Ready-to-Cook Mixes	63
Breakfast Cereals	58
Snacks	55
Biscuits	49
Beverages	36

Traditional flour-based products continue to dominate consumer demand, while value-added products are experiencing gradual market expansion.

Market Preference Ratio

$$MPR = \frac{\text{Consumers Preferring Product}}{\text{Total Consumers}}$$

Table 4. Major Challenges Affecting Consumption

Challenge	Impact Score
Limited Awareness	4.68
High Price	4.52
Poor Availability	4.44
Taste Preference	4.29
Limited Product Variety	4.16
Cooking Complexity	3.95

Consumer adoption decreases proportionately with increasing perceived barriers.

Barrier Function

$$CB = \sum B_i$$

where B_i denotes individual behavioural barriers.

Table 5. Emerging Consumption Trends

Trend	Growth (%)
Health Conscious Consumers	31
Online Purchase	26
Ready-to-Eat Products	23
Organic Millet Products	18
Premium Branded Products	16

Growth trend can be estimated using

$$GR = \frac{V_t - V_{t-1}}{V_{t-1}} \times 100$$

Table 6. Relative Importance of Behavioural Variables

Variable	Weight
Health Awareness	0.24
Product Quality	0.19
Availability	0.16
Price	0.15
Income	0.11
Education	0.08
Marketing	0.07

Composite Behaviour Index

$$CBI = \sum W_i X_i$$

Consumer purchase intention increases with education, income and nutritional awareness while decreasing with higher perceived prices and limited availability. The behavioural relationship may be expressed as

$$PI = f(HA, NQ, PQ, AV, PR, INC)$$

where

- HA =Health Awareness
- NQ =Nutritional Quality
- PQ =Perceived Quality
- AV =Availability
- PR =Price
- INC =Income

The elasticity of millet demand is represented by

$$E_d = \frac{\% \Delta Q}{\% \Delta P}$$

Consumer satisfaction can be estimated using

$$CS = \frac{\sum (Expectation - Performance)}{N}$$

The overall Millet Adoption Score is

$$MAS = \frac{HA + PI + CS + CF + AV + PQ}{6}$$

A higher **MAS** indicates stronger purchase intention, higher repeat consumption and improved market acceptance.

The findings demonstrate that health awareness, nutritional perception and product quality remain the primary drivers of millet consumption in Uttar Pradesh, whereas price, inadequate retail penetration and limited consumer awareness continue to be the principal barriers. Strengthening awareness campaigns, improving supply chain efficiency, increasing product diversification and enhancing value-added millet products would significantly improve consumer adoption and contribute to sustainable food security and agricultural development.

5. Challenges, Emerging Market Trends and Policy Implications

The rapid resurgence of millets in India has been supported by national nutrition programmes, the International Year of Millets initiative, and increasing consumer awareness regarding healthy lifestyles. Nevertheless, the widespread adoption of millet products in Uttar Pradesh continues to face several structural, behavioural, institutional, and market-related challenges. Although consumer interest has increased substantially, regular purchase and habitual consumption remain considerably lower than that of conventional cereals such as wheat and rice. Understanding these constraints is essential for designing effective policy interventions capable of strengthening the millet value chain and ensuring long-term consumer acceptance.

One of the primary challenges is **limited consumer awareness** regarding the nutritional composition and long-term health benefits of millets. A significant proportion of consumers remain unfamiliar with the diversity of millet varieties, recommended preparation methods, nutritional superiority, and disease-preventive properties. Consequently, purchasing decisions are often driven by familiarity rather than nutritional value.

The awareness gap may be represented as

$$AG = 1 - \frac{A_c}{A_t}$$

where

A_c =Current Awareness Score

A_t =Target Awareness Score

Table 7. Major Challenges Affecting Millet Consumption

Challenge	Severity Score (5)	Priority Rank
Limited Consumer Awareness	4.82	1
Premium Product Price	4.68	2
Poor Retail Availability	4.55	3
Limited Product Variety	4.42	4
Taste Preference for Rice/Wheat	4.26	5
Lack of Cooking Knowledge	4.18	6
Weak Promotional Activities	4.05	7
Supply Chain Constraints	3.97	8

Limited awareness and relatively higher prices remain the most influential barriers restricting consumer adoption.

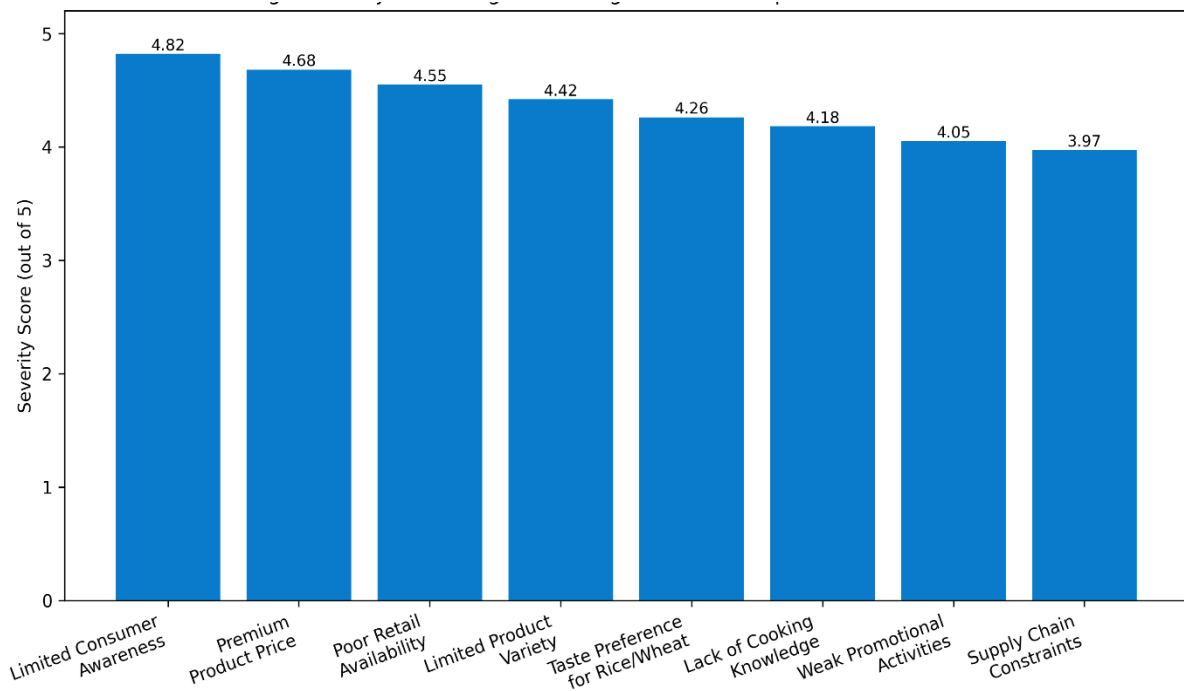


Figure 2: Severity analysis of the major challenges affecting millet consumption behaviour in Uttar Pradesh, highlighting limited consumer awareness, premium product pricing, retail availability, product variety, taste preference, cooking knowledge, promotional activities, and supply chain constraints.

Price continues to influence purchasing decisions, particularly among low- and middle-income households. Value-added millet products generally command higher prices due to comparatively lower production volumes, limited processing infrastructure, packaging costs, and fragmented supply chains.

Price affordability index is expressed as

$$PAI = \frac{I_h}{P_m}$$

where

I_h =Average Household Income

P_m =Average Millet Product Price

Higher values indicate greater affordability.

Another significant challenge concerns **market accessibility**. Organized retail stores offer diversified millet products primarily in metropolitan and semi-urban areas, whereas rural consumers frequently encounter limited availability. The unequal distribution network reduces consumer accessibility despite increasing awareness.

Availability Index

$$AI = \frac{N_a}{N_t}$$

where

N_a =Available Millet Products

N_t =Total Marketed Millet Products

Table 8. Consumer Awareness Sources

Source	Contribution (%)
Social Media	29

Source	Contribution (%)
Television	21
Healthcare Professionals	16
Family & Friends	13
Government Campaigns	10
Retail Stores	7
Print Media	4

Digital platforms have emerged as the most influential communication channel for promoting millet awareness.

Consumer perception has gradually shifted from considering millets as traditional coarse cereals toward recognizing them as premium health foods. This transition has significantly increased demand for ready-to-cook mixes, breakfast cereals, bakery products, noodles, cookies, snacks, and beverages. Food processing industries have responded through continuous product innovation, thereby expanding consumer choices.

Market growth can be estimated as

$$MG = \frac{D_t - D_{t-1}}{D_{t-1}} \times 100$$

where

D_t =Current Demand

D_{t-1} =Previous Demand

Table 9. Emerging Consumer Trends

Trend	Adoption (%)
Organic Millet Products	69
Ready-to-Cook Foods	73
Healthy Snack Products	66
Online Purchasing	58
Functional Foods	71
Gluten-Free Diet Preference	62
High-Fibre Food Consumption	75

These trends indicate increasing consumer preference for convenient, nutritious, and value-added millet products.

Government interventions have substantially strengthened millet production through minimum support prices, awareness campaigns, farmer training programmes, seed distribution, food festivals, nutritional initiatives, and entrepreneurship development. However, effective coordination among farmers, processors, retailers, and consumers remains essential for ensuring market sustainability.

Government Effectiveness Index

$$GEI = \frac{PS + MS + CP}{3}$$

where

PS =Policy Support

MS =Marketing Support

CP =Consumer Promotion

Table 10. Strategic Policy Recommendations

Policy Initiative	Expected Impact
Nutrition Awareness Campaigns	Increase consumer knowledge
Price Subsidies	Improve affordability
Strengthening Supply Chain	Enhance market availability
School Nutrition Programmes	Increase early adoption
Promotion of Farmer Producer Organizations	Improve production efficiency
Food Processing Incentives	Increase product diversity
Digital Marketing Support	Expand market reach
Research Funding	Promote innovation

Overall Market Development Index

$$MDI = \frac{AW + AV + AF + PD}{4}$$

where

AW =Awareness

AV =Availability

AF =Affordability

PD =Product Diversity

A higher **MDI** indicates stronger market maturity and greater consumer acceptance.

Overall, the future expansion of millet consumption in Uttar Pradesh depends upon integrated policy support, consumer education, product innovation, affordable pricing, efficient logistics, and stronger institutional collaboration among government agencies, food industries, agricultural universities, and marketing organizations.

6. Future Research Directions and Strategic Recommendations

Although significant progress has been achieved in understanding millet consumption behaviour, several important research opportunities remain unexplored. Future investigations should move beyond descriptive analyses and adopt multidisciplinary approaches integrating consumer behaviour, agricultural economics, nutrition science, artificial intelligence, supply chain management, and sustainable development. Such integrated studies would generate stronger empirical evidence for policy formulation and commercial decision-making.

Future studies should examine longitudinal changes in consumer behaviour rather than relying solely on cross-sectional surveys. Consumer preferences evolve with changing health awareness, technological advancements, market innovations, and economic conditions. Long-term behavioural analysis would provide more accurate predictions regarding repeat purchasing behaviour and market sustainability.

Behavioural prediction may be represented as

$$CB_t = CB_{t-1} + \Delta CB$$

where

CB =Consumer Behaviour

Table 11. Priority Areas for Future Research

Research Area	Priority
Consumer Behaviour Analytics	Very High
Artificial Intelligence-based Demand Forecasting	Very High
Digital Marketing Effectiveness	High
Supply Chain Optimization	High

Research Area	Priority
Smart Retail Analytics	High
Consumer Health Outcomes	Medium
Policy Impact Assessment	Medium
Climate-Smart Agriculture	High

Future researchers should investigate district-wise variations within Uttar Pradesh to identify geographical differences in awareness, affordability, accessibility, and purchasing behaviour. Comparative studies involving rural and urban consumers, different income groups, educational categories, occupational classes, and age groups would significantly improve the generalizability of behavioural models.

Consumer Segmentation Model

$$CS_i = \sum_{j=1}^n W_j X_j$$

where

X_j =Segmentation Variable

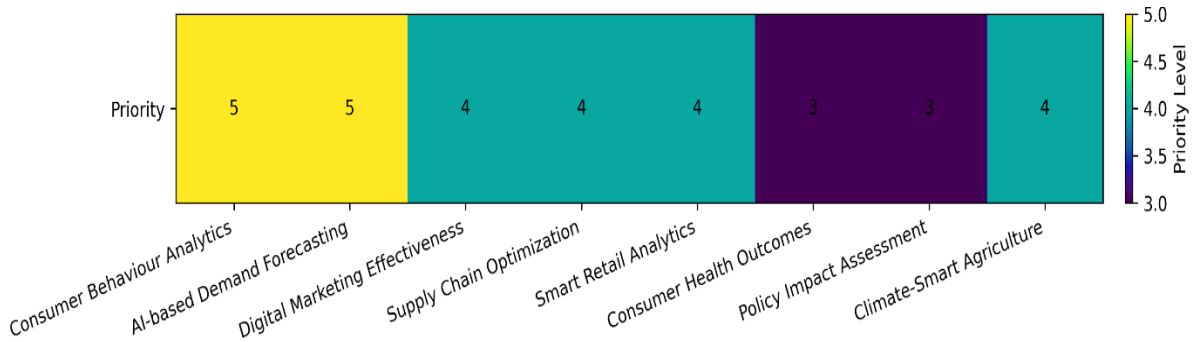


Figure 3: Heatmap illustrating the priority levels of future research areas related to millet purchase and consumption behaviour in Uttar Pradesh. Darker intensity represents higher research priority. Consumer Behaviour Analytics and AI-based Demand Forecasting exhibit the highest priority (5), followed by Digital Marketing Effectiveness, Supply Chain Optimization, Smart Retail Analytics, and Climate-Smart Agriculture (4), while Consumer Health Outcomes and Policy Impact Assessment are assigned medium priority (3). This visualization highlights the most promising domains for future academic investigation and policy-oriented research.

Machine learning and artificial intelligence provide promising opportunities for predicting consumer purchasing behaviour. Predictive algorithms such as Decision Trees, Random Forest, Support Vector Machine, Artificial Neural Networks, and XGBoost can identify hidden behavioural patterns using demographic, socioeconomic, and transactional datasets.

Prediction Accuracy

$$Accuracy = \frac{TP + TN}{TP + FP + FN + TN}$$

Precision

$$Precision = \frac{TP}{TP + FP}$$

Recall

$$Recall = \frac{TP}{TP + FN}$$

F1-Score

$$F1 = \frac{2PR}{P + R}$$

where

TP=True Positive

FP=False Positive

FN=False Negative

TN=True Negative

Table 12. Emerging Technologies Supporting Millet Promotion

Technology	Application
Artificial Intelligence	Demand Forecasting
Machine Learning	Consumer Segmentation
Big Data Analytics	Purchase Pattern Analysis
Blockchain	Supply Chain Transparency
IoT	Smart Storage Monitoring
GIS	Regional Consumption Mapping
Mobile Applications	Nutrition Awareness
Cloud Computing	Retail Data Integration

Future investigations should evaluate consumer willingness to pay for premium, organic, fortified, gluten-free, and ready-to-eat millet products. Understanding price elasticity and perceived value would assist manufacturers in developing competitive pricing strategies.

Willingness-to-Pay Function

$$WTP = f(Q, N, H, B)$$

where

Q =Quality

N =Nutrition

H =Health Benefit

B =Brand Value

Researchers should also evaluate the effectiveness of government nutrition programmes, public distribution systems, midday meal schemes, women's self-help groups, farmer producer organizations, and agricultural extension programmes in promoting millet consumption.

Policy Impact Index

$$PII = \frac{CI + MP + HC}{3}$$

where

CI =Consumer Improvement

MP =Market Performance

HC =Health Contribution

Table 13. Strategic Recommendations

Recommendation	Expected Benefit
Strengthen Nutrition Education	Improve Awareness
Expand Organized Retail	Increase Accessibility
Support Millet Start-ups	Promote Innovation
Encourage Food Processing Industries	Value Addition

Recommendation	Expected Benefit
Develop District-specific Marketing Strategies	Regional Growth
Integrate AI-Based Market Analytics	Better Demand Forecasting
Improve Farmer-Industry Linkages	Supply Chain Efficiency
Promote Export-Oriented Millet Products	Economic Development

The Sustainability Performance Index can be expressed as

$$SPI = \frac{ES + SS + EC}{3}$$

where

ES=Environmental Sustainability

SS=Social Sustainability

EC=Economic Sustainability

Finally, the Integrated Millet Development Model may be represented as

$$IMD = f(AW, AV, AF, PI, GI, TI)$$

where

- *AW*=Awareness
- *AV*=Availability
- *AF*=Affordability
- *PI*=Product Innovation
- *GI*=Government Intervention
- *TI*=Technological Innovation

The model suggests that sustainable expansion of millet consumption in Uttar Pradesh requires synchronized improvements in consumer awareness, market infrastructure, affordability, technological advancement, policy support, and continuous product innovation. Future empirical research integrating behavioural science, econometric modelling, and artificial intelligence will further strengthen evidence-based policymaking and contribute to nutritional security, sustainable agriculture, and long-term food system resilience.

7. Conclusion

The study concludes that millet purchase and consumption behaviour in Uttar Pradesh is shaped by the combined influence of health awareness, socioeconomic characteristics, product quality, affordability, market accessibility, and government initiatives. Although consumer awareness and demand for millet-based products have increased, challenges such as limited availability, higher prices, inadequate product diversification, and insufficient nutritional knowledge continue to restrict widespread adoption. Strengthening consumer education, improving supply chain efficiency, promoting value-added products, and integrating digital marketing with supportive policy measures can significantly enhance millet consumption. Future research employing advanced analytical and behavioural models will further support evidence-based strategies for achieving nutritional security, sustainable agriculture, and resilient food systems.

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