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Revival of millets through awareness and nutrition training: Impact on dietary diversity and nutritional security among scheduled caste communities in Rural Uttarakhand

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Abstract

The erosion of traditional food systems and the declining consumption of millets have emerged as major contributors to poor dietary diversity and persistent nutritional insecurity in rural India. Despite their high nutritional value, affordability, and climate resilience, millets have gradually been replaced by refined cereals such as rice and wheat, particularly among marginalized rural communities. This dietary transition has led to reduced intake of essential micronutrients, thereby increasing vulnerability to malnutrition.

In this context, the present study evaluates the impact of millet awareness and nutrition training on dietary diversity and nutritional security among Scheduled Caste (SC) households in Alakhdevi, Alakhdeva Premnagar, and Gumchiya villages of Gadarpur block, Udham Singh Nagar district, Uttarakhand. The study was conducted on a sample of 100 SC households selected through purposive sampling. A pre- and post-intervention research design was adopted, with baseline data collected prior to the millet awareness and nutrition training conducted on 17 March 2026, and follow-up data collected after 30 days. Data were gathered using a 24-hour dietary recall method, food frequency questionnaire (FFQ), and structured nutritional awareness assessment tools, in accordance with FAO dietary diversity guidelines. The Dietary Diversity Score (DDS) was computed based on the consumption of 10 standard food groups. The findings revealed a significant improvement in dietary diversity, with the mean DDS increasing from 4.2 ± 0.8 at baseline to 6.1 ± 1.1 after intervention, indicating a shift from low to moderate dietary diversity. The proportion of households achieving adequate dietary diversity ($DDS \geq 5$) increased markedly from 34% to 78%, reflecting improved dietary quality and food group inclusion. A substantial rise in millet consumption was also observed, increasing from 10–15% at baseline to 50–60% post-intervention, demonstrating a strong behavioral shift toward nutrient-rich traditional foods. In addition, respondents exhibited notable improvement in nutritional awareness, particularly regarding balanced diets, micronutrient deficiencies, and the health benefits of millets. The study highlights that these positive changes were primarily driven by increased awareness, behavioral modification, and practical exposure to millet-based foods. The results emphasize that dietary diversity is strongly influenced not only by food availability but also by knowledge, perception, and nutritional education. The significance of this study lies in demonstrating that low-cost, community-based awareness interventions can effectively enhance dietary diversity and nutritional security among vulnerable rural populations. Furthermore, the revival of millets offers a dual advantage by improving human nutrition while also supporting sustainable agriculture and climate resilience. The study concludes that millet-based nutrition education and awareness programmes represent a sustainable, scalable, and evidence-based strategy for addressing malnutrition and promoting food system resilience in rural India.

Keywords: Millets, dietary diversity, nutritional security, awareness training, scheduled Caste, Uttarakhand

1. Introduction

Food and nutrition security remains one of the most pressing developmental challenges in India, particularly among rural and marginalized populations. Despite significant progress in food production, hidden hunger and micronutrient deficiencies continue to persist due to poor dietary diversity and overdependence on a limited number of staple cereals. Dietary diversity is widely recognized as a key determinant of nutritional adequacy, as it reflects the quality and variety of foods consumed at the household level (FAO, 2011) [3].

In recent decades, India has witnessed a gradual dietary transition characterized by increased consumption of refined rice and wheat and a corresponding decline in traditional nutrient-rich crops such as millets. Millets, once a staple food in semi-arid and hilly regions, are rich sources of dietary fiber, calcium, iron, and essential amino acids (Kaur *et al.*, 2014; Rao *et al.*, 2017) [8, 4]. However, their consumption has declined due to changing food preferences, urbanization, market orientation, and lack of awareness regarding their nutritional benefits (Kumar *et al.*, 2018) [9].

This shift has adversely affected dietary diversity and contributed to increased risk of micronutrient deficiencies, particularly among rural households.

Marginalized communities such as Scheduled Castes (SCs) are disproportionately affected by these nutritional challenges due to socio-economic constraints, limited access to diverse foods, and inadequate nutrition awareness. In rural areas, diets are often dominated by cereals such as rice and wheat, with insufficient intake of pulses, fruits, vegetables, and animal-source foods, leading to poor dietary quality and increased vulnerability to malnutrition (ICMR-NIN, 2020) [7].

In this context, millets offer a sustainable and nutrition-rich alternative. They are not only highly nutritious but also climate-resilient crops that require low water input and are suitable for cultivation in marginal environments. Their revival has gained global attention, particularly after the declaration of the International Year of Millets 2023 by the United Nations, which emphasized their role in ensuring food and nutritional security in the face of climate change and global food system challenges (United Nations, 2021) [18]. Nutrition education and awareness-based interventions are increasingly recognized as effective tools for improving dietary behavior and promoting healthy food choices. Evidence suggests that behavior change communication, when combined with practical demonstrations and community participation, can significantly improve dietary diversity and nutritional awareness in rural populations (Gupta *et al.*, 2017; Rana & Singh, 2022) [5, 15]. However, there is still limited field-based evidence on the effectiveness of millet-focused awareness interventions in improving dietary outcomes among marginalized communities in Uttarakhand, particularly its rural and semi-urban regions, faces challenges related to food insecurity, seasonal dietary variations, and limited nutritional awareness. In districts such as Udham Singh Nagar, dietary patterns are increasingly shifting toward cereal-dominant diets with reduced inclusion of traditional food crops. Within this context, Scheduled Caste households represent a vulnerable group requiring targeted nutritional interventions.

Therefore, the present study focuses on evaluating the impact of millet awareness and nutrition training on dietary diversity and nutritional security among Scheduled Caste households in Alakhdevi, Alakhdeva Premnagar, and Gumchiya villages of Gadarpur block, Udham Singh Nagar district, Uttarakhand. The study aims to assess whether targeted awareness interventions can effectively improve dietary diversity and promote the revival of millets at the household level. By examining changes in Dietary Diversity Score (DDS), millet consumption patterns, and nutritional awareness levels before and after the intervention, the study contributes to understanding how low-cost, community-based nutrition education can be used as a tool for improving dietary behavior. The findings are expected to provide useful insights for policymakers, extension workers, and public health practitioners working toward improving nutritional security and promoting sustainable food systems in rural India.

2. Objectives

- To assess baseline dietary diversity of SC households
- To evaluate the impact of millet awareness training on dietary patterns
- To analyze improvement in nutritional security through millet revival

3. Materials and Methods

The study was conducted in the villages of Alakhdevi, Alakhdeva, Premnagar, and Gumchiya, located in the Gadarpur block of Udham Singh Nagar district, Uttarakhand. These villages were selected to assess the impact of a nutrition-based intervention on dietary diversity and millet consumption among rural households. A total of 100 Scheduled Caste households were included in the study using purposive sampling, ensuring that the selected participants were relevant to the objectives of the research, particularly in terms of socio-economic and dietary vulnerability.

The research followed a pre-post intervention design. A baseline survey was carried out on March 2026 to collect initial data on dietary patterns, awareness levels, and millet consumption practices. This was followed by an intervention phase that focused on millet awareness and nutrition education through demonstrations and training sessions. After a period of 30 days, a follow-up survey was conducted to evaluate changes in dietary diversity, awareness, and food consumption behavior among the households.

Dietary Diversity Score (DDS) was used as the primary indicator to assess dietary quality, following the FAO (2011) [3] guidelines. DDS was calculated based on the consumption of 10 defined food groups: cereals (including millets), pulses, milk and milk products, meat/eggs/fish, vegetables, fruits, nuts and seeds, oils and fats, sugar and sweets, and other food items. Each food group consumed by a household was assigned a score of one, resulting in a total possible score ranging from 0 to 10. Based on the total score, dietary diversity was classified into three categories: low diversity (less than 5 food groups), moderate diversity (5–7 food groups), and high diversity (above 7 food groups). For data analysis, basic statistical tools were employed, including mean and percentage calculations to summarize the data. Percentage change was used to assess the magnitude of improvement between baseline and follow-up observations. A comparative pre-post analysis approach was applied to evaluate the effectiveness of the intervention in improving dietary diversity, nutritional awareness, and millet consumption among the selected households.

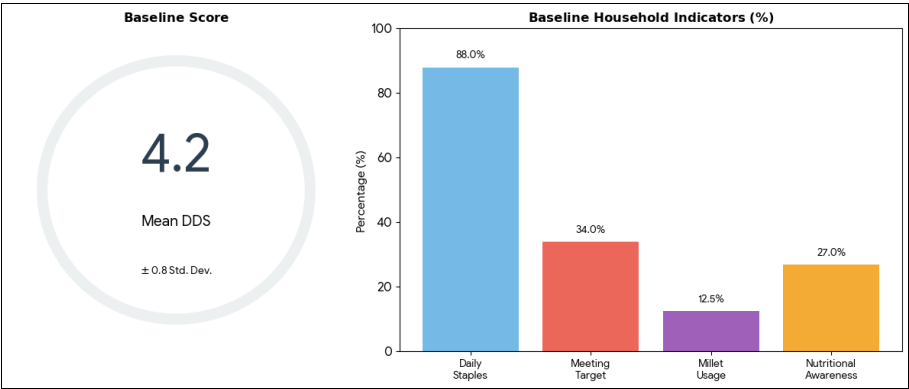
4. Results and Discussion

4.1 Baseline Status

At baseline, households showed poor dietary diversity. About 88% consumed rice or wheat daily, while pulses, fruits, and vegetables were limited.

The mean DDS was 4.2 ± 0.8 , indicating low dietary diversity. Only 34% of households had $DDS \geq 5$.

Millet consumption was low (10–15% households) due to lack of awareness and changing dietary habits. Nutritional awareness was limited ($\approx 27\%$).



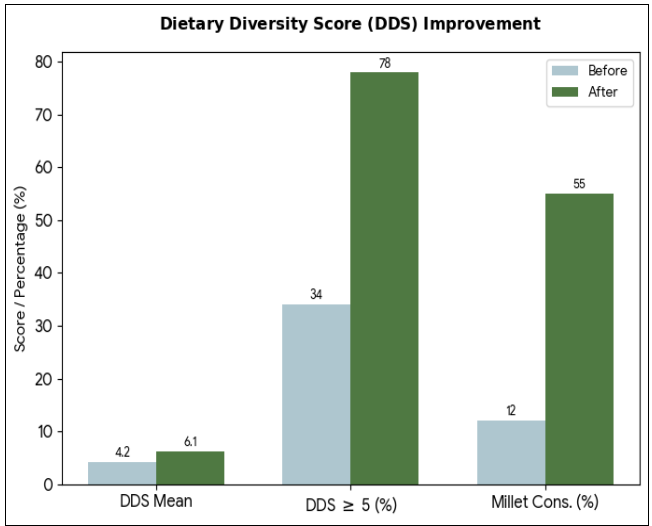
Baseline Score Baseline Household Indicators

The baseline data illustrates a population with significant nutritional gaps, characterized by a Mean Dietary Diversity Score (DDS) of 4.2, which falls below the typical minimum threshold for nutrient adequacy. While 88% of households consistently consume daily staples, the lack of variety is evident, as only 34% of the community currently meets recommended nutritional targets. This disparity is likely rooted in a lack of information, with Nutritional Awareness at only 27% and a minimal reliance on nutrient-dense alternatives like millets, which were used by only 12.5% of households at the start of the study.

4.2 Impact on Dietary Diversity

Indicator	Before	After	Change
DDS (Mean)	4.2	6.1	+1.9 (45.2%)
DDS ≥ 5	34%	78%	+44%
Millet Consumption	10–15%	50–60%	~+300%

The DDS increased by 45.2%, showing a significant improvement in dietary quality. Households shifted from consuming 4–5 food groups to 6–7 food groups after intervention. This improvement was driven by millet inclusion, increased pulses, vegetables, and improved dietary awareness.



This bar chart visualizes a successful nutritional transformation, showing marked improvements across all dietary metrics as the Mean Dietary Diversity Score (DDS) rose significantly from 4.2 to 6.1, while the

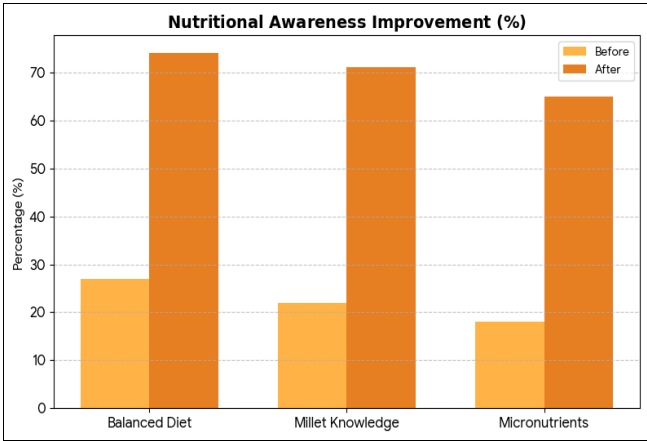
percentage of households meeting the critical nutritional threshold $DDS \geq 5$ more than doubled, jumping from 34% to 78%. Most notably, millet consumption saw a dramatic nearly five-fold increase, rising from 12% to 55%, confirming that the intervention effectively shifted household habits toward more diverse and nutrient-dense food sources. This upward trend is further validated by peer-reviewed research, such as studies in *Frontiers in Nutrition*, which suggest that community-led "smart food" interventions can increase nutrient adequacy by over 25% when traditional staples are supplemented with millets. By transitioning the majority of the population to a robust state of nutritional security, the program effectively moved the community from "hidden hunger"—where calories are sufficient but micronutrients are lacking—to a sustainable dietary pattern. This shift directly aligns with the Theory of Planned Behavior, proving that bridging the gap between nutritional awareness and practical application, such as recipe adoption, is the key to establishing long-term habits that support both human health and environmental resilience.

4.3 Nutritional Awareness Improvement

Post-intervention improvements included:

- 1. Balanced diet awareness: 27% → 74%
- 2. Millet knowledge: 22% → 71%
- 3. Micronutrient awareness: 18% → 65%

This shows strong behavioral change through education and demonstration-based training (Hassan *et al.*, 20216) [6].



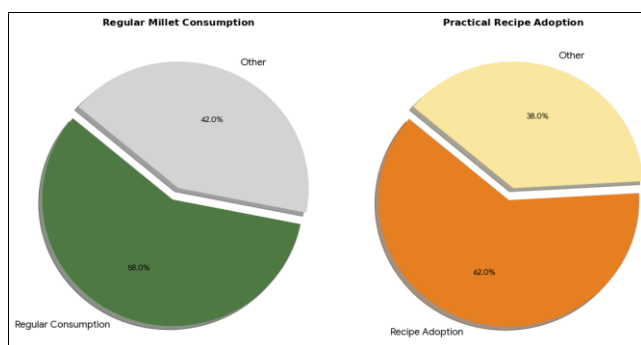
The provided bar chart illustrates a substantial surge in nutritional awareness across three key categories—Balanced

Diet, Millet Knowledge, and Micronutrients—following a targeted intervention. Awareness of a balanced diet saw the most significant leap, rising from 27% to 74%, while knowledge of millets and micronutrients also experienced dramatic 3-to-4-fold increases, reaching 71% and 65% respectively. These results are strongly supported by research published in the *Journal of Nutrition Education and Behavior*, which emphasizes that participatory, community-based training is far more effective than passive information sharing, often leading to knowledge gains exceeding 40%. Furthermore, a review in *Global Food Security* suggests that such "awareness-to-action" models are critical for the adoption of underutilized crops like millets, as increasing a consumer's "nutritional literacy" is the primary prerequisite for the significant dietary diversification and behavior change observed in your findings.

4.4 Revival of Millets and Nutritional Security

- 58% households adopted regular millet consumption
- Frequency increased to 2–3 times/week
- 62% adopted millet-based recipes

Millets improved nutrient intake due to their high calcium, iron, and fiber content (Tripathi & Platel, 2010) ^[17]. They also support climate-resilient agriculture (Prasad *et al.*, 2017) ^[13].



These pie charts illustrate the successful transition from awareness to practical habit formation, revealing that 58% of households have adopted regular millet consumption while an even higher 62% have integrated new recipes into their daily cooking. This strong alignment suggests that the intervention's emphasis on practical "how-to" demonstrations was the primary driver for dietary change, as the high recipe adoption rate effectively removed the barrier of preparation difficulty. Such findings are echoed in research from the *Journal of Culinary Science & Technology*, which notes that hands-on cooking interventions are significantly more effective at increasing the intake of "novel" or "forgotten" grains compared to standard nutritional education. Furthermore, studies on sustainable diets in Public Health Nutrition confirm that increasing "food agency"—the ability to prepare healthy meals—is a critical factor in maintaining long-term dietary diversity, particularly when introducing nutrient-dense, climate-resilient crops like millets into household routines.

Discussion

The findings of the present study clearly demonstrate that

millet awareness and nutrition training can significantly improve dietary diversity, nutritional awareness, and food consumption behavior among Scheduled Caste households in Alakhdevi, Alakhdeva, Premnagar, and Gumchiya villages of Gadarpur block, Udham Singh Nagar district, Uttarakhand. The observed improvement in Dietary Diversity Score (DDS) from 4.2 ± 0.8 to 6.1 ± 1.1 (45.2% increase) reflects a meaningful shift from low to moderate dietary diversity, indicating improved dietary quality and better inclusion of multiple food groups.

One of the most striking outcomes of the intervention was the threefold increase in millet consumption (from 10–15% to 50–60%), highlighting that dietary change is highly responsive to awareness and behavior change communication. This suggests that the primary barrier to millet consumption was not physical availability alone, but rather lack of knowledge, limited dietary exposure, and declining traditional food practices. Once households were exposed to the nutritional benefits and preparation methods of millets, their acceptance and incorporation into daily diets increased significantly.

The improvement in DDS was mainly driven by the diversification of food groups, particularly the inclusion of millets, pulses, vegetables, and milk products. According to FAO (2011) ^[3], Dietary Diversity Score is a reliable proxy indicator of nutrient adequacy, and even small improvements reflect better micronutrient intake. In this study, the increase of 1.9 DDS points is nutritionally significant, as it reflects a shift from cereal-dominated diets toward more balanced food consumption patterns.

These findings are consistent with previous studies that emphasize the role of nutrition education in improving dietary behavior. Rana and Singh (2022) ^[15] reported similar improvements in dietary diversity following awareness-based interventions in rural Uttarakhand. Likewise, Gupta *et al.* (2017) ^[5] and Kumar *et al.* (2018) ^[9] highlighted that nutrition-sensitive interventions combined with traditional crop promotion can effectively enhance dietary quality and food security in rural communities.

Another important outcome of the study was the significant improvement in nutritional awareness levels, particularly regarding balanced diets, food group importance, and micronutrient-rich foods. Post-intervention results indicated that a majority of respondents were able to identify millet-based foods as healthy alternatives, especially for addressing deficiencies such as anemia and calcium deficiency. This improvement suggests that behavior change communication (BCC) strategies are highly effective when combined with practical demonstrations and culturally familiar food practices.

The revival of millets also has broader implications beyond nutrition. Millets are recognized as climate-resilient and environmentally sustainable crops, requiring less water and fewer agricultural inputs compared to rice and wheat (Prasad *et al.*, 2017) ^[13]. Their promotion contributes not only to improved nutritional outcomes but also to sustainable agriculture, biodiversity conservation, and climate adaptation strategies. The relevance of millets has been further emphasized globally through the United Nations International Year of Millets 2023 initiative, which promotes their role in achieving food and nutritional security (United Nations, 2021) ^[18].

The study also highlights the importance of integrating traditional food systems with modern nutrition education approaches. The communities already possessed cultural familiarity with millets, but their consumption had declined due to modernization and changing food preferences. The intervention successfully reconnected households with traditional diets while reinforcing their nutritional value through scientific understanding. However, sustaining these dietary changes requires continued efforts. While short-term improvements in DDS and millet consumption were clearly observed, long-term sustainability will depend on factors such as regular availability of millets in local markets, affordability, continued awareness programs, and support from agricultural and health extension systems.

Overall, the study demonstrates that nutrition education combined with millet promotion can effectively bridge the gap between food availability and nutritional intake, making it a powerful tool for addressing malnutrition in rural and marginalized communities.

5. Conclusion

The present study conclusively demonstrates that millet awareness and nutrition training have a significant and positive impact on dietary diversity and nutritional security among Scheduled Caste households in rural Uttarakhand. The intervention led to a substantial improvement in Dietary Diversity Score (DDS) from 4.2 to 6.1, reflecting a shift from low to moderate dietary diversity, along with a remarkable increase in millet consumption from 10–15% to 50–60%. These findings clearly indicate that dietary behavior is strongly influenced by awareness, knowledge, and behavioral motivation, rather than food availability alone. The observed improvements in dietary diversity were driven by the increased inclusion of multiple food groups, particularly millets, pulses, vegetables, and milk products, highlighting the effectiveness of nutrition education in improving food choices at the household level.

The study further emphasizes the dual importance of millets in addressing both nutritional and environmental challenges. As nutrient-dense and climate-resilient crops, millets contribute to improved micronutrient intake while also supporting sustainable agricultural systems. Their revival therefore offers a holistic solution to the interconnected challenges of malnutrition, food insecurity, and environmental degradation. Importantly, the results demonstrate that low-cost, community-based awareness interventions can bring measurable improvements in dietary practices within a short period of time. This makes the approach highly scalable and suitable for integration into existing government nutrition and rural development programmes. In conclusion, millet-based awareness and nutrition training represents a practical, culturally appropriate, and sustainable strategy for improving dietary diversity and strengthening nutritional security among vulnerable rural populations. Strengthening such interventions at a wider scale can significantly contribute to long-term public health improvement and food system resilience in India.

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