



Assessment of Farmers' Knowledge on Nutrition and Nutrition-Sensitive Agriculture

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HIGHLIGHTS

- A standardized knowledge test was developed and validated to assess the knowledge level of respondents regarding nutrition and nutrition-sensitive agriculture (NSA).
- Farmers possess a basic nutrition knowledge; however, enhancing knowledge on innovative NSA technologies and institutional programs remains imperative.
- Regional disparities in knowledge scores emphasise the importance of targeted interventions, particularly in Karnataka, to bridge existing knowledge gaps.

ARTICLE INFO

Keywords: Nutritional knowledge, Nutrition-sensitive agriculture, Welch's t-test, Regression analysis, Socio-economic characteristics.

<https://doi.org/10.48165/IJEE.2026.62115>

Citation: Abrar, P. N. F., Satyapriya, Barua, S., Mahra, G. S., Bishnoi, S., Ray, M., Khan, S. A., Roy, S. K., Ranjan, A., & Nath, R. K. (2026). Assessment of farmers' knowledge on nutrition and nutrition-sensitive agriculture. *Indian Journal of Extension Education*, 62(1), 92-98. <https://doi.org/10.48165/IJEE.2026.62115>

ABSTRACT

Nutritional knowledge plays a vital role in shaping the dietary behaviour of individuals and communities. This study assessed farmers' knowledge of nutrition and nutrition-sensitive agriculture (NSA) in the southern Indian states of Kerala and Karnataka during 2024-25. A standardized knowledge test comprising 26 statements was developed and administered to a sample of 300 respondents. Statistical analyses, including Welch's t-test, Welch's ANOVA, and the Games-Howell post-hoc test, were used to compare knowledge scores across states and districts. In addition, regression analysis was employed to examine the relationship between farmers' knowledge and socio-economic characteristics. State- and district-level comparisons indicated that farmers from Kerala had higher knowledge levels than those from Karnataka. Regression analysis revealed that factors such as education, gender, age, source of information, number of trainings attended, and family size significantly influenced farmers' knowledge. These disparities underscore the necessity of awareness campaigns and capacity-building programs on nutrition and NSA, particularly through educational institutions, rural organizations, and mass media platforms.

INTRODUCTION

Despite significant progress in agricultural productivity and food security over recent decades, malnutrition continues to pose a persistent public health challenge across many regions of India (United Nations in India, 2023). According to the National Family

Health Survey-5 (NFHS-5, 2019-21), 35.50 per cent of children under five are stunted, 19.30 per cent are wasted, and 32.10 per cent are underweight, with wide disparities across states (International Institute for Population Sciences [IIPS] and ICF, 2021). These figures highlight the limitations of conventional food security approaches that prioritize caloric sufficiency over dietary

Received 28-11-2025; Accepted 17-12-2025

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diversity and nutritional adequacy. Although overall calorie availability has increased, the quality of diets, particularly in rural communities, remain deficient in essential micronutrients, causing widespread undernutrition, anaemia, and other diet-related health conditions (Ruel et al., 2018; Jose et al., 2020). In this context, NSA has become an essential approach for enhancing health outcomes and tackling malnutrition, especially in regions where agriculture remains the backbone of rural livelihoods. Conventional agricultural practices usually focus on maximising crop yields and economic returns, whereas NSA integrates nutrition goals by promoting farming practices that enhance dietary diversity, food quality, and the nutritional value of local diets (Herforth & Ballard, 2016). These strategies include enhancing access to safe and nutritious food, reducing health risks through sustainable agricultural practices, strengthening nutrition knowledge and norms, increasing household income, and fostering women's empowerment (Ogotu et al., 2020). Farmers, being the primary producers of food, are very important in shaping the dietary behaviour of households and community. Their understanding of dietary diversity, nutritional value of crops & livestock, and benefits of farm diversification directly influence production decisions and household consumption patterns. However, despite their pivotal role, evidence remains limited on how much farmers know about nutrition and how far this knowledge shapes their agricultural practices, especially in the context of NSA (Channal et al., 2024).

Kerala and Karnataka, two southern Indian states, offer contrasting yet instructive cases for exploring farmers' knowledge of nutrition and NSA. Both states perform relatively strong performance in human development and agricultural diversification compared to the national average; however, they differ considerably in health indicators, agricultural policies, and extension systems. Although Kerala is widely recognized for its outstanding social development, as reflected in its high literacy rate of 96.20 per cent (National Statistical Office, 2019), a life expectancy at birth of 75.30 years (National Health Systems Resource Centre, 2021), and a comparatively well-established healthcare infrastructure, the state continues to face challenges related to dietary monotony and micronutrient deficiencies, particularly among tribal and other marginalized communities (Natuvilakkandy & Christabell, 2025). Karnataka, in contrast, demonstrates wide variation in socio-economic conditions and farming systems, where certain regions adopting rapid agricultural innovations while others still struggle with persistent nutrition-related challenges (Rao et al., 2022). Hence, this study investigates the extent of farmers' knowledge regarding nutrition and NSA in Kerala and Karnataka and identify the socio-economic factors shaping their understanding.

METHODOLOGY

The study was conducted during 2024-25 in the southern Indian states of Kerala and Karnataka to assess farmers' knowledge regarding nutrition and NSA. A total of six districts were selected randomly, three from Kerala (Wayanad, Palakkad, and Alappuzha) and three from Karnataka (Dharwad, Kolar, and Mandya). Then, a stratified random sample of 50 farmers was drawn from each district, comprising individuals who were practicing at least two of the four selected NSA technologies, namely kitchen garden, millet

cultivation, crop diversification, and value addition. Hence, the total sample size of the study was 300 respondents. A knowledge test consisting of 26 items (knowledge statements) was developed to measure farmers' knowledge. Initially, 36 items were identified based on their relevance to nutrition and NSA, drawing from literature reviews and expert suggestions. These items were then evaluated for appropriateness by subject-matter experts through email consultation, following the procedure outlined by Kumar et al. (2016). After the relevancy test, five items were removed, leaving 31 items, which were further pilot-tested on 48 farmers outside the study area. Respondents were asked to record their answers, with each correct response assigned a score of "1" and each incorrect response a score of "0." The total knowledge score for each item was calculated by summing the individual respondent scores (Kaur et al., 2020). Item analysis was carried out following the standard procedures outlined by Vijayan et al. (2022) and Barua et al. (2023). Out of the 31 items, 26 satisfied the established selection criteria, i.e., a difficulty index between 30 and 80, a discrimination index exceeding 0.30, and a point-biserial correlation coefficient above 0.236. Hence, these 26 items were retained for the final knowledge test (Table 1).

To quantify the percentage knowledge of farmers on each item, a standardized knowledge index (KI) was calculated using the following formula:

$$\text{Knowledge Index (KI)} = \frac{\text{Obtained score}}{\text{Maximum obtainable score}} \times 100$$

The maximum obtainable score for an item was 300. Further, Welch's t-test was applied to compare the mean knowledge scores of farmers in Kerala and Karnataka, while Welch's ANOVA, followed by Games-Howell post-hoc tests, was used for district-wise comparisons. Similar procedures for state- and district-wise comparisons were used by Ranjan et al. (2025). To examine the relationship between farmers' knowledge levels and independent variables, multiple linear regression analysis was conducted using SPSS (version 25). The assumption of linearity was verified, and collinearity statistics, namely Tolerance and the Variance Inflation Factor (VIF), were calculated to assess the extent of multicollinearity (Barua et al., 2023).

RESULTS

The item-wise analysis of farmers' knowledge, presented in Table 2, revealed considerable variation across different concepts. Overall, the percentage of correct responses ranged from 32 per cent to 96 per cent, reflecting differential levels of understanding among respondents. With respect to general nutrition knowledge, most respondents answered correctly on items such as the importance of drinking sufficient water (96%), the variation of nutritional requirements by age, gender, and activity level (90.67%), good hand hygiene practices (94%), and the health risks associated with junk food consumption (92.33%). Similarly, high levels of knowledge were observed regarding the health detriments of skipping meals (91.33%), the inclusion of fruits and vegetables in the daily diet (88%), maintaining ideal body weight (85.33%), and the importance of dietary diversity (84.67%). However, several

Table 1. Item analysis of questionnaire for testing farmers' knowledge about nutrition and NSA (n=48)

S.No.	Knowledge items	Difficulty Index	Discrimination Index	Point-Biserial Correlation (Rpbis)
1.	Dietary diversity indicates access to a variety of foods within a household - T/F	68.75	0.38	0.41**
2.	Balanced diet is essential for good health - T/F	54.17	0.50	0.54**
3.	The consumption of fruit juice is better than consuming raw fruit - T/F	56.25	0.63	0.57**
4.	Skipping meals is good for health - T/F	72.92	0.38	0.44**
5.	A healthy diet depends on drinking enough water - T/F	79.17	0.31	0.45**
6.	Maintaining ideal body weight is essential for good health - T/F	70.83	0.50	0.47**
7.	Sprouting will improve nutrient availability - T/F	64.58	0.44	0.36*
8.	Drinking tap water is good for health - T/F	68.75	0.38	0.32*
9.	Nutritional requirement varies based on factors such as age, gender, and activity level -T/F	75.00	0.56	0.63**
10.	It is healthier to include fruits and vegetables in our daily diet - T/F	62.50	0.44	0.40**
11.	Inclusion of dairy product is necessary in our diets - T/F	66.67	0.38	0.32*
12.	Anaemia is due to deficiency of iron consumption - T/F	64.58	0.44	0.36*
13.	Frequent intake of junk food is good for health - T/F	62.50	0.50	0.43**
14.	Washing hands before consuming food is an important hygiene habit - T/F	70.83	0.38	0.36*
15.	Excess intake of fat may cause obesity - T/F	72.92	0.31	0.47**
16.	What is the major objective of NSA?	47.92	0.75	0.58**
	a) Increased crop yields			
	b) Lower production costs			
	c) Better nutrition outcomes			
17.	Promoting only staple crops is sufficient for achieving better nutrition outcomes – T/F	56.25	0.63	0.57**
18.	Nutri-sensitive Agricultural Resources and Innovations (NARI) and Value Addition and Technology Incubation Centres in Agriculture (VATICA) are two major programs of Indian Council of Agricultural Research (ICAR) to promote NSA - T/F	33.33	0.56	0.51**
19.	Kitchen garden as an NSA technology provide fresh, organic, and nutritious produce for the household consumption - T/F	77.08	0.44	0.48**
20.	Regular participation in nutrition training is important because it:	62.50	0.44	0.40**
	a) Focuses only on technical farming methods			
	b) Updates farmers on NSA production and consumption practices			
	c) Promotes pesticide use			
21.	NSA technologies do not consider environmental sustainability - T/F	68.75	0.38	0.35*
22.	Promoting dietary diversity through the cultivation of various crops and livestock is integral to NSA – T/F	64.58	0.44	0.36*
23.	Which of the NSA practice is most likely improve soil health & increase nutrient content in crops?	56.25	0.63	0.57**
	a) Crop rotation			
	b) Monocropping			
	c) Excessive use of chemical fertilizers			
24.	Milletts are nutritional powerhouses, packed with a lot of health benefits – T/F	64.58	0.38	0.37**
25.	Value addition reduce postharvest losses and improve nutritious food availability across different seasons – T/F	52.08	0.50	0.50**
26.	What is the primary benefit of introducing bio-fortified crops? a) Pest resistance b) Enhanced micronutrient content c) Higher market value	47.92	0.63	0.62**

** Significant at 1% LOS, *Significant at 5% LOS

misconceptions were evident. For instance, only 68.67 per cent of respondents recognized that consuming fruit juice is not necessarily better than eating whole fruit, and only 66 per cent correctly identified the nutritional benefits of sprouting. Likewise, while 72.67 per cent correctly linked anaemia to iron deficiency, a considerable proportion failed to demonstrate this fundamental nutrition knowledge. Regarding NSA specific knowledge, respondents displayed a generally good understanding of key NSA principles and practices. The majority identified the major objective of NSA as improving nutrition outcomes (82%) and acknowledged the importance of diversified farming systems (84.33%) and kitchen

gardens (90.67%) as essential NSA technologies providing fresh, nutritious produce for households. Practices such as crop rotation were correctly identified by 77.33 per cent of respondents as beneficial for soil health and nutrient content, and value addition was recognized by 78.67 per cent for its role in reducing postharvest losses and improving seasonal availability of nutritious foods. Similarly, 78.67 per cent rejected the misconception that NSA technologies do not consider environmental sustainability, demonstrating reasonable awareness of the environmental dimensions of NSA. In contrast, a notable knowledge gap emerged regarding institutional and technical aspects of NSA. Only 32 per cent of

Table 2. Statement-wise knowledge among respondents regarding nutrition and NSA (n=300)

Q.No.	Knowledge items	CR	KI (%)
1.	Dietary diversity indicates access to a variety of foods within a household	True	84.67
2.	Balanced diet is essential for good health	True	62.67
3.	The consumption of fruit juice is better than consuming raw fruit	False	68.67
4.	Skipping meals is good for health	False	91.33
5.	A healthy diet depends on drinking enough water	True	96.00
6.	Maintaining ideal body weight is essential for good health	True	85.33
7.	Sprouting will improve nutrient availability	True	66.00
8.	Drinking tap water is good for health	False	89.33
9.	Nutritional requirement varies based on factors such as age, gender, and activity level	True	90.67
10.	It is healthier to include fruits and vegetables in our daily diet	True	88.00
11.	Inclusion of dairy product is necessary in our diets	True	78.67
12.	Anaemia is due to deficiency of iron consumption	True	72.67
13.	Frequent intake of junk food is good for health	False	92.33
14.	Washing hands before consuming food is an important hygiene habit	True	94.00
15.	Excess intake of fat may cause obesity	True	79.33
16.	What is the major objective of NSA? a) Increased crop yields b) Lower production costs c) Better nutrition outcomes	c	82.00
17.	Promoting only staple crops is sufficient for achieving better nutrition outcomes	False	79.33
18.	Nutri-sensitive Agricultural Resources and Innovations (NARI) and Value Addition and Technology Incubation Centres in Agriculture (VATICA) are two major programs of Indian Council of Agricultural Research (ICAR) to promote NSA	True	32.00
19.	Kitchen garden as an NSA technology provide fresh, organic, & nutritious produce for the household consumption	True	90.67
20.	Regular participation in nutrition training is important because it: a) Focuses only on technical farming methods b) Updates farmers on NSA production and consumption practices c) Promotes pesticide use	b	72.00
21.	NSA technologies do not consider environmental sustainability	False	78.67
22.	Promoting dietary diversity through the cultivation of various crops and livestock is integral to NSA	True	84.33
23.	Which of the NSA practice is most likely improve soil health and increase nutrient content in crops? a) Crop rotation b) Monocropping c) Excessive use of chemical fertilizers	a	77.33
24.	Milletts are nutritional powerhouses, packed with a lot of health benefits	True	80.67
25.	Value addition reduce postharvest losses and improve nutritious food availability across different seasons	True	78.67
26.	What is the primary benefit of introducing bio-fortified crops? a) Pest resistance b) Enhanced micronutrient content c) Higher market value	b	51.67

CR = Correct Response, KI = Knowledge Index

respondents were aware of flagship ICAR programs such as Nutri-sensitive Agricultural Resources and Innovations (NARI) and Value Addition and Technology Incubation Centres in Agriculture (VATICA), indicating limited exposure to formal NSA initiatives. Awareness of primary benefits of bio-fortified crops was moderate, with just 51.67 per cent correctly identifying this, suggesting insufficient dissemination of information regarding these advanced NSA innovations. Moreover, only 72 per cent recognized the importance of regular nutrition training for updating NSA production and consumption practices.

A comparison of knowledge scores between respondents from Kerala and Karnataka is summarized in Figure 1. The mean knowledge score was higher in Kerala (20.90) compared to Karnataka (18.99). Statistical analysis using Welch's t-test ($t = 4.96$, $p = 1.24 \times 10^{-6}$) confirmed that the difference in knowledge scores

between the two states was significant. The effect size was moderate (Cohen's $d = 0.57$), with a 95 per cent confidence interval ranging from 0.34 to 0.80. While, the district-wise comparison of farmers' knowledge scores, illustrated in Figure 2, revealed that respondents in Alappuzha (20.66) and Wayanad (20.42) districts of Kerala had the highest average knowledge scores, whereas those in Kolar (18.40) and Dharwad (19.10) districts of Karnataka had the lowest. Statistical analysis using Welch's ANOVA indicated a significant variation in knowledge scores across districts ($F = 6.17$, $p = 3.46 \times 10^{-5}$), with a moderate effect size ($\eta^2 = 0.18$). Post-hoc pairwise comparisons using the Games-Howell test further revealed that respondents in Alappuzha had significantly higher knowledge scores compared to those in Kolar (mean difference = 3.22, $p = 1.19 \times 10^{-3}$) and Dharwad (mean difference = 2.16, $p = 0.04$).

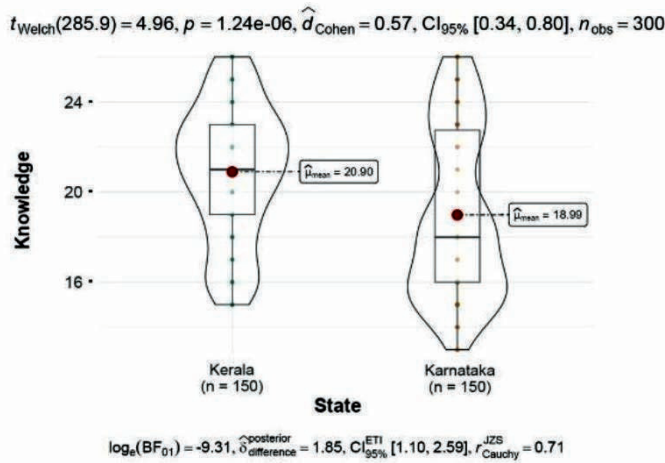


Figure 1. State-wise Comparison of Knowledge Scores: Kerala vs. Karnataka (Violin plot)

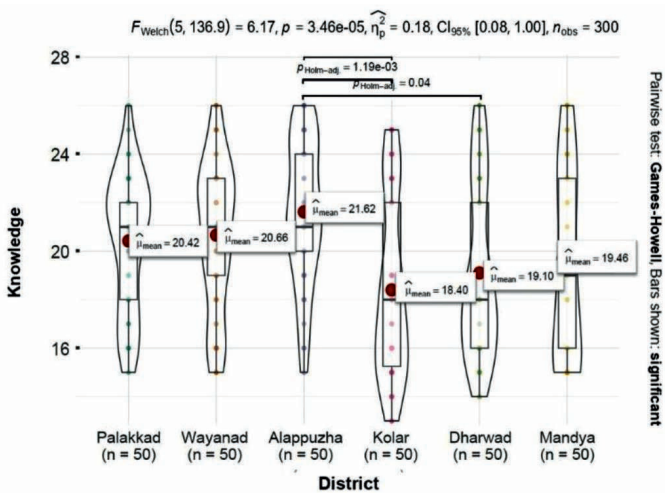


Figure 2. District-wise Comparison of Knowledge Scores (Violin plot)

The results of the regression analysis, presented in Table 3, highlight the key factors influencing farmers’ knowledge of nutrition and NSA. Six independent variables viz., age, education, family size, gender, source of information, and number of NSA-related trainings attended were found to explain approximately 74.60 per cent of

the variation in the dependent variable, i.e., knowledge level. The same table also presents the collinearity statistics, which were computed to assess the presence of multicollinearity. Generally, a VIF value less than 5 and a tolerance value greater than 0.20 are considered acceptable, indicating a low correlation between a given independent variable and other predictor variables. In this study, all independent variables had VIF values below 5 and tolerance values above 0.20, confirming the absence of significant multicollinearity. Therefore, no variables were excluded from the model on account of multicollinearity.

DISCUSSION

The item-wise analysis of farmers’ knowledge about nutrition and NSA revealed that respondents generally demonstrated a strong understanding of fundamental nutrition practices. These included dietary diversity, the importance of safe water consumption, hand hygiene, and the avoidance of junk food. Such findings are in line with earlier studies which highlighted the effectiveness of public health campaigns in improving community-level nutrition literacy (Ruel & Alderman, 2013; FAO, 2017). However, certain misconceptions persisted, particularly regarding the nutritional value of fruit juice compared to raw fruits and the benefits of food sprouting. This reflects previous reports that popular dietary myths frequently misguide food choices (Girard et al., 2012), underscoring the need for more nuanced nutrition education that reinforces correct practices in daily food-related decisions. With respect to NSA, knowledge levels were relatively high in areas such as crop rotation, kitchen gardening, and diversified farming. This suggests a growing recognition of the interlinkages between agriculture, nutrition, and sustainability, which aligns with global evidence demonstrating that household-level agroecological interventions significantly contribute to improved dietary diversity and nutrition outcomes (Fanzo et al., 2020). Nevertheless, the low awareness of institutional NSA programs such as ICAR’s NARI and VATICA points to critical gaps in extension outreach and policy communication in India, a challenge similarly highlighted in evaluations of agricultural-nutrition linkages in developing contexts (Gillespie et al., 2013). Limited knowledge about the benefits of bio-fortification also suggests insufficient dissemination of innovations that have been shown to effectively address micronutrient deficiencies in agrarian

Table 3. Determinants of farmers’ knowledge about nutrition and NSA (n=300)

Characteristics	Regression coefficient	Standard error	t-value	Collinearity statistics	
				Tolerance	VIF
Age	-0.097**	0.030	-3.195	0.319	3.131
Education	0.489**	0.057	8.632	0.385	2.599
Total annual income	1.797×10^{-7}	0.000	0.005	0.737	1.357
Family type	-0.013	0.381	-0.033	0.428	2.336
Family size	-0.286*	0.114	-2.518	0.372	2.687
Gender	-0.683**	0.245	-2.784	0.825	1.212
Farming experience	0.012	0.029	0.411	0.467	2.142
Social participation	0.000	0.075	-0.004	0.805	1.242
Source of information	0.630**	0.088	7.161	0.585	1.709
No. of trainings attended	0.326**	0.111	2.946	0.789	1.267
Market access	-0.072	0.118	-0.611	0.690	1.448

** Significant at 1% LOS, *Significant at 5% LOS

communities (Bouis & Saltzman, 2017). A state-wise comparison revealed significantly higher knowledge scores among respondents in Kerala compared to those in Karnataka. At the district level, Kerala's districts, particularly Alappuzha (21.62), outperformed their counterparts in Karnataka, including Kolar (18.40) and Dharwad (19.10). These findings support earlier work by Channal et al. (2024), who reported that 62 per cent of rural women in Dharwad had inadequate nutrition knowledge, while only 7.40 per cent demonstrated adequate understanding. The observed regional differences may reflect disparities in educational infrastructure, the effectiveness of local nutrition campaigns, and access to NSA-related extension services. This aligns with previous evidence on substantial geographic variation in nutrition literacy and program exposure across Indian states (Ruel, 2003). Although the effect size was moderate, Kerala's population benefits from factors that encourage acquisition and retention of nutrition knowledge. The results further emphasize the pivotal role of socio-economic variables in shaping farmers' knowledge. Education emerged as a strong determinant, consistent with evidence that links educational attainment to both agricultural and health literacy (Contento & Koch, 2020). Gender differences were also significant: the negative coefficient indicated that female respondents held higher knowledge levels than their male counterparts. Similar trends were also reported by Barua et al. (2023). A negative association with age suggests generational differences in exposure to modern information sources, highlighting the need for tailored outreach targeting older populations. Family size influenced knowledge levels as well, possibly reflecting resource constraints that hinder both knowledge acquisition and practical application, in line with socio-economic theories of household resource distribution (Gillespie et al., 2013).

The overall findings of the study indicate that while farmers possess a solid foundation of basic nutrition awareness, enhancing knowledge on innovative NSA technologies and institutional programs remains imperative. Therefore, targeted strategies such as strengthening extension services, promoting context-appropriate best practices, and enhancing access to educational resources in lagging regions, are essential to bridging existing knowledge gaps. Such efforts would support equitable improvements in nutrition literacy, dietary practices, and long-term public health outcomes (Fanzo et al., 2020). Incorporating participatory extension approaches and integrating nutrition education into existing agricultural advisory services will be essential to improve farmer capacity to adopt NSA strategies (Girard et al., 2012). Moreover, promoting sustained nutrition training can bridge technical knowledge gaps and foster behavioural change (Ruel & Alderman, 2013).

CONCLUSION

The state and district-wise comparisons of knowledge scores indicated regional disparities, while, regression analysis highlighted the significant influence of socio-economic factors such as education, gender, age, source of information, trainings attended, and family size on farmers' knowledge. Overall, the findings reaffirm that while baseline awareness of nutrition and NSA exists, substantial scope remains for improving knowledge levels and ensuring effective translation into practice. Targeted, region-specific,

and gender-sensitive interventions are essential to bridge gaps, particularly in Karnataka. Strengthening the dissemination of institutional programs, enhancing extension and educational outreach, and addressing persistent misconceptions will be key to promoting equitable nutrition literacy and sustainable agricultural practices. By doing so, policies and programs can better foster the integration of agriculture and nutrition, ultimately contributing to improved dietary diversity and long-term public health outcomes.

DECLARATIONS

Ethics approval and informed consent: Informed consent was sought from the farmer respondents during the course of the research.

Acknowledgements: The authors are grateful to Indian Council of Agricultural Research (ICAR), Department of Agricultural Research and Education (DARE), Government of India and University Grants Commission (UGC) for providing financial support and technical guidance to carry out the research study, data compilation and analysis. The authors are thankful to all the respondents for their cooperation.

Conflict of interest: The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The authors declare that during the preparation of this work, they thoroughly reviewed, revised, and edited the content as needed. The authors take full responsibility for the final content of this publication.

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