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Pre–post changes in postharvest knowledge and self-reported practices following YouTube-based microlearning among mango farmers in the Konkan Region of Maharashtra

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Abstract

Postharvest losses in mango value chains remain a major concern in India, partly because small and medium mango growers do not consistently adopt recommended harvesting, handling, packaging, disease-management, and ripening practices. This study examined changes in postharvest knowledge and self-reported practice adoption among mango farmers in Maharashtra following exposure to a structured series of Marathi-language YouTube microlearning videos. A one-group pre-test/post-test quasi-experimental design was implemented during the mango harvest season among 500 participating growers from the Konkan region. Knowledge was assessed using a 20-item instrument, while adoption was measured using six predefined postharvest practice indicators. Mean knowledge scores increased from 8.56 ± 2.92 to 16.02 ± 3.21 out of 20, with a mean change of 7.46 points (95 % CI: 7.26–7.66; paired t = 73.23, $P < 0.001$; Wilcoxon V = 0, $P < 0.001$; Cohen's dz = 3.27). Mean adoption scores increased from 2.15 ± 1.17 to 4.20 ± 1.41 out of 6, with a mean change of 2.05 practices (95 % CI: 1.97–2.14; paired t = 47.65, $P < 0.001$; Wilcoxon V = 0, $P < 0.001$; Cohen's dz = 2.13). Practice-wise McNemar tests showed significant pre–post increases across all six adoption indicators. Engagement was substantial but uneven: 44.0% of participants reported watching 9–10 videos, while 24.0% watched 6–8 videos. The findings suggest that locally contextualised YouTube microlearning may complement conventional horticultural extension by improving postharvest knowledge and encouraging reported adoption of recommended practices. However, because the study lacked a non-exposed comparison group and relied mainly on self-reported adoption, causal attribution should be interpreted cautiously.

Key words: Mango, postharvest management, digital extension, microlearning, YouTube, practice adoption, Maharashtra, Konkan

Introduction

Mango is among India's most important horticultural crops and is economically significant in Maharashtra's Konkan region, particularly in districts known for Alphonso mango production. Despite the value of the crop, postharvest losses remain a persistent constraint in mango value chains. Losses arise from premature or improper harvesting, sap injury, bruising during transport, poor grading, inadequate packaging, fungal infection, unsuitable ripening methods and weak temperature management (FAO, 2011a; Kader, 2005; Murthy *et al.*, 2009; Le *et al.*, 2022; Kiran *et al.*, 2023). For smallholders and semi-commercial growers, such losses do not merely reduce physical quantity; they also reduce marketable quality, price realisation and confidence in formal value-chain participation.

Recommended postharvest practices for mango are well documented in horticultural manuals and extension literature. These include harvesting at appropriate physiological maturity, retaining a short pedicel, de-sapping, careful sorting and grading, rigid crate-based transport, hygienic disease-management treatments where approved, controlled ethylene ripening, avoidance of calcium carbide, and storage at cultivar-appropriate temperature and relative humidity (FAO, 2011b; National Horticulture Board, 2000; Sargent *et al.*, 2010). However, the availability of technical information does not automatically translate into adoption. Farmers often require repeated, practical, locally understandable and visually demonstrative communication to convert recommendations into field-level behaviour.

Conventional extension systems continue to play an important role, but they face structural constraints in reach, frequency and timing. In harvest-sensitive commodities, a farmer may need guidance precisely when a practice is to be performed, not weeks before or after. Farmer-to-extension-worker ratios, seasonal labour demands and the dispersion of growers across villages make repeated face-to-face demonstration difficult. Digital media has therefore emerged as a potential complement to conventional extension rather than a substitute (Aker, 2011; Asenso-Okyere *et al.*, 2010; Swanson and Rajalahti, 2010; World Bank, 2017; Rajkhowa and Qaim, 2021; Singh *et al.*, 2023).

Video-based extension is especially relevant where practices require demonstration. Short instructional videos may reduce cognitive load by presenting one operation at a time and may be revisited when farmers need procedural clarity (Bentley *et al.*, 2014; Bentley *et al.*, 2019; Bentley *et al.*, 2022). YouTube is widely accessible through smartphones and is already used informally by many farmers for agricultural information; WhatsApp-based video sharing has further extended reach in rural India (Coggins *et al.*, 2024). However, evidence on YouTube as a deliberately structured microlearning intervention for

horticultural postharvest management remains limited, although Mishra and Faisal (2024) recently examined YouTube specifically as a knowledge-sharing platform for mango cultivation. This study addresses that gap by examining changes in knowledge and reported adoption following a Marathi-language YouTube microlearning intervention for mango growers in Maharashtra.

The adoption of a new practice is shaped by perceived relative advantage, compatibility with existing routines, complexity, trialability and observability, broadly consistent with earlier reviews of agricultural innovation adoption in developing countries (Feder *et al.*, 1985). Microlearning videos can make postharvest practices more observable by showing procedures visually, reduce perceived complexity by segmenting practices into short modules, and support trialability by encouraging farmers to attempt individual steps during the harvest season. The use of Marathi and locally familiar examples was intended to increase compatibility with farmers' linguistic and operational context. The intervention design was conceptually informed by Diffusion of Innovations theory (Rogers, 2003) rather than intended as an empirical test of the theory: none of the constructs above (relative advantage, compatibility, complexity, trialability, observability) were directly measured in this study.

Materials and methods

Study design: The study used a one-group pre-test/post-test quasi-experimental design. Participating mango farmers completed a baseline assessment before exposure to the video series and a post-intervention assessment after completion of the five-week microlearning sequence. Data collection was conducted during the 2025 Alphonso mango harvest season, broadly between March and May, over an intervention period of approximately five weeks. Exact baseline, intervention and post-assessment dates were not centrally retained, which is acknowledged as a documentation limitation. This design permits estimation of pre–post change associated with exposure to the intervention. Still, it does not permit strong causal attribution because it includes no untreated or non-exposed comparison group. During the harvest season, farmers may also have received information from traders, peers, input dealers, extension personnel or other digital sources. Therefore, the results are interpreted as significant post-intervention changes associated with exposure to the YouTube microlearning series rather than definitive proof that the videos alone caused the observed changes.

Study area and participants: The study was conducted in Maharashtra's Konkan region, with participating growers recruited through village-level mobilisation and local networks in mango-growing locations across Ratnagiri and Sindhudurg. Purposive sampling was used to include farmers who were actively engaged in mango cultivation during the study period and could be reached for both pre- and post-intervention assessment. The final analytic sample included 500 farmers who completed both assessments. Purposive sampling is appropriate for a digital intervention feasibility study but limits the statistical generalisability of findings beyond comparable digitally reachable mango-growing communities. The retained dataset contains 500 matched baseline and follow-up records. Records of the total number of farmers approached, screened or declining participation were not preserved. Consequently, we could not reconstruct a complete recruitment-flow diagram, which we acknowledge as a documentation limitation. The sample size was determined pragmatically by the number of eligible and digitally reachable farmers available across the selected locations during the intervention period; no prospective power calculation was undertaken.

District-wise classification was reconstructed from the village/taluka names recorded in the data sheet. Ratnagiri-side locations included Rajapur, Mandangad, Khed, Guhagar, Dapoli, Ratnagiri, Lanja and Chiplun. Sindhudurg-side locations included Sawantwadi, Sindhudurg, Vengurla, Malvan, Kudal, Devkarwadi and Kankavli.

Table 1. Socio-demographic and digital profile of participating mango farmers

Variable	Category / summary	n	% / Mean ± SD
District	Ratnagiri-side locations	261	52.2%
District	Sindhudurg-side locations	239	47.8%
Age	Mean age (years)	500	42.02 ± 11.60
Gender	Male	381	76.2%
Gender	Female	113	22.6%
Gender	Other	6	1.2%
Education	No formal	62	12.4%
Education	Primary	100	20.0%
Education	Middle	104	20.8%
Education	Secondary	108	21.6%
Education	Higher secondary	81	16.2%
Education	Graduate and above	45	9.0%
Schooling	Mean years of schooling	500	7.62 ± 4.09
Total landholding	Mean acres	500	3.20 ± 1.89
Mango area	Mean acres	500	1.76 ± 1.25
Mango farming experience	Mean years	500	24.72 ± 11.90
Smartphone ownership	Yes	431	86.2%
Smartphone ownership	No	69	13.8%
Prior YouTube agriculture use	Often	126	25.2%
Prior YouTube agriculture use	Sometimes	179	35.8%
Prior YouTube agriculture use	Rarely	100	20.0%
Prior YouTube agriculture use	Never	95	19.0%
WhatsApp use	Daily	250	50.0%
WhatsApp use	Weekly	111	22.2%
WhatsApp use	Rarely	42	8.4%
WhatsApp use	Never	97	19.4%

Intervention: YouTube microlearning video series*:* The intervention consisted of ten short Marathi-language videos of approximately 3–5 minutes each. The videos were designed as microlearning units, with each video focusing on one operational postharvest practice. Links were shared to farmers via WhatsApp over five weeks during the mango harvest season, at a frequency of two videos per week. Farmers with limited digital literacy were assisted in accessing videos and were shown how to open links, subscribe to the channel and replay videos when required. The intervention was deliberately timed so that farmers could attempt recommended practices during the ongoing harvest period.

The technical content of the video series was prepared using recognised postharvest recommendations and reviewed for local relevance by horticultural experts before field dissemination. Exact public URLs and platform-level retention metrics were not retained in the analysis file; this is acknowledged as a documentation limitation. For future extension use, the video series should be archived as a stable playlist, with the release date,

Table 2. Description of the YouTube microlearning video intervention.

Video	Title/topic	Key recommendation	Language	Approximate duration
V1	Harvest maturity and safe harvesting	Harvest at physiological maturity; use clean clippers or pole harvester; retain short pedicel; avoid dropping fruit.	Marathi	3–5 min
V2	De-sapping and cleaning	Keep fruit stem-end down on an inclined surface after harvest; clean and shade fruit before packing.	Marathi	3–5 min
V3	Field sorting and grading	Separate damaged, diseased and immature fruits; grade by size and maturity.	Marathi	3–5 min
V4	Plastic crates and transport	Use rigid plastic crates or protective packaging; avoid overfilling, gunny bags and rough handling.	Marathi	3–5 min
V5	Shade holding and field heat reduction	Keep harvested fruit in shade and reduce field heat before longer transport where feasible.	Marathi	3–5 min
V6	Hot-water treatment and disease management	Use approved disease-management practices only where technically appropriate and locally permitted.	Marathi	3–5 min
V7	Safe ripening	Use controlled ethylene-based ripening methods and avoid calcium carbide.	Marathi	3–5 min
V8	Storage temperature and humidity	Maintain cultivar-appropriate cool storage and humidity; avoid chilling injury.	Marathi	3–5 min
V9	Quality checks before sale	Inspect for bruising, sap burn, decay and uneven maturity; remove infected fruit from market lots.	Marathi	3–5 min
V10	Integrated workflow recap	Follow sequence: harvest, de-sap, sort/grade, treat if approved, dry, pack, transport and ripen safely.	Marathi	3–5 min

view count, average watch time and retention data preserved for auditability.

Knowledge instrument and validation: Postharvest knowledge was assessed using a structured 20-item binary-scored questionnaire covering maturity assessment, harvesting, de-sapping, sorting/grading, packaging, disease-management precautions, ripening and storage. Each correct answer was scored 1 and each incorrect answer 0, giving a total possible score of 0–20. Horticultural subject experts reviewed the instrument for content relevance, and it was pilot-tested with farmers before field administration. We simplified ambiguous wording before the main survey. We examined internal consistency using KR-20 because the items were dichotomously scored. KR-20 was 0.45 at baseline, 0.73 at post-test and 0.84 in the pooled pre/post item set. The weak baseline reliability may reflect heterogeneous content domains, restricted item discrimination, differences in item difficulty, or translation-related issues, rather than heterogeneous prior knowledge alone; total-score findings should therefore be interpreted cautiously. Because pre- and post-test administrations differ substantially and are not independent, the pooled pre/post KR-20 figure above should not be treated as the instrument's principal reliability estimate.

Adoption measurement: Practice adoption was measured through six predefined binary indicators, each scored 0 for not adopted and 1 for adopted. The composite adoption scores therefore ranged from 0 to 6. Adoption was based primarily on farmer self-report collected during the post-intervention harvest-season assessment. Because field observation and photographic verification were not consistently available for all respondents, interpret the adoption findings as reported adoption rather than independently verified behavioural change. The same six practice indicators were recorded for the same farmers at baseline and follow-up; however, the retained questionnaire did not document a formally standardised recall period, which limits interpretation of the baseline-to-follow-up comparison. The six practice indicators were summed as a formative practice index rather than a reflective psychometric scale. Equal weighting was used to provide a transparent count of reported recommended practices; it does not imply that all six practices are equally costly, equally feasible or equally applicable under every farming condition. Practice-specific results (Table 5) are therefore reported alongside the composite score so that the index is not read as a validated measurement scale. Two of the six indicators are broad composite items: "fungicidal dip / hot-water treatment" combines two distinct treatments, and "controlled ethylene ripening/avoidance of calcium carbide" combines two distinct behaviours. The retained dataset did not permit retrospective disaggregation, so these are interpreted as formative composite indicators rather than measures of individually equivalent practices.

Engagement measurement: Engagement was assessed using self-reported exposure variables, including videos watched, average completion, rewatching, sharing and whether the participant required assisted viewing. These data strengthen interpretation of exposure but do not replace platform-level analytics such as click-through rate, watch-time logs or retention curves.
Statistical analysis: Knowledge and composite adoption scores were analysed using paired t-tests. Mean differences, 95 %

Table 3. Operational definitions for the six adoption indicators

Practice indicator	Operational definition of adoption	Verification basis
Harvest tool use	Farmer reported using a pole harvester, clippers or comparable tool-based harvesting method rather than dropping, shaking or rough removal of fruits.	Self-report
Field sorting/grading	Farmer reported separating fruits by damage, disease symptoms, size or maturity before packing/marketing.	Self-report
Plastic crates/proper packaging	Farmer reported using rigid crates or protective packaging and avoiding overfilled sacks/gunny bags for transport.	Self-report
Fungicidal dip / hot-water treatment	Farmer reported using an approved postharvest disease-management dip or hot-water treatment where locally appropriate.	Self-report
Improved ripening	Farmer reported using ethylene/safe ripening methods or avoiding calcium carbide-based ripening.	Self-report
De-sapping and cleaning	Farmer reported following de-sapping and basic cleaning before packing or sale.	Self-report

confidence intervals and Cohen's dz were calculated to report the magnitude of change. We examined the normality of paired difference scores using the Shapiro–Wilk test. Because difference scores deviated significantly from normality, Wilcoxon signed-rank tests were also reported as non-parametric sensitivity analyses. Practice-wise changes in binary adoption indicators were tested using McNemar's test with continuity correction, with discordant-pair counts reported to improve auditability (McNemar, 1947). The six practice-wise comparisons were prespecified, and Holm-adjusted p values were calculated to control the family-wise error rate. Spearman correlations were used to examine bivariate associations between farmer characteristics and knowledge gain. An adjusted ordinary least-squares regression model used post-test knowledge as the dependent variable, with baseline knowledge, age, years of schooling and total landholding entered as predictors. IBM SPSS Statistics for Windows, version 22.0 (IBM Corp., Armonk, NY, USA), was used for data management and primary analyses. Wilcoxon signed-rank tests used two-sided asymptotic inference, with post-test minus baseline defining the direction of change. HC3 heteroskedasticity-robust standard errors for the adjusted regression and Holm-adjusted p values were calculated and independently verified using Python 3 with statsmodels version 0.14.6. Statistical significance was set at $P < 0.05$.

Ethical considerations: Formal institutional ethics review was not obtained before data collection. Participation was voluntary, informed consent was obtained, and no identifying information is reported. This absence of prospective ethics review is acknowledged as a limitation. Data were used exclusively for research purposes. Farmers were informed that the videos were advisory and that chemical or ripening treatments should be followed only when consistent with approved labels, safety rules, residue limits and buyer or export-market requirements.

Results

Participant completion and engagement: All 500 participants completed both baseline and post-intervention assessments and were included in the analysis. Engagement was substantial but uneven. A total of 220 participants (44.0%) reported watching 9–10 videos, and 120 participants (24.0%) reported watching 6–8 videos. In terms of completion, 144 participants (28.8%) reported watching videos mostly in full, and 134 participants (26.8%) reported watching more than half of the videos. Rewatching and peer sharing were also observed: 167 participants (33.4%) rewatched at least one video, and 206 participants (41.2%) shared videos with others. Completion-category responses were retained for 278 of the 500 participants; the remaining respondents' completion category was not preserved in the retained dataset. Percentages for "mostly full" and "more than half" above are therefore calculated against the full analytic sample (n = 500) rather than against a complete set of completion categories, and this gap is treated as a documentation limitation rather than resolved by recalculating against a partial denominator.

Table 4. Self-reported engagement with the YouTube microlearning series.

Engagement indicator	Category	n	%
Videos watched	0–2 videos	76	15.2
Videos watched	3–5 videos	84	16.8
Videos watched	6–8 videos	120	24.0
Videos watched	9–10 videos	220	44.0
Average completion	Mostly full video	144	28.8
Average completion	More than half	134	26.8
Rewatched any video	Yes	167	33.4
Shared videos	Yes	206	41.2
Viewing assistance	Assisted/shared viewing mode	62	12.4

Knowledge and adoption score changes: Baseline knowledge was modest, with a mean score of 8.56 ± 2.92 out of 20. Following the intervention, the mean score increased to 16.02 ± 3.21. The mean knowledge gain was 7.46 points (95 % CI: 7.26–7.66). The paired t-test was statistically significant (t = 73.23, df = 499, $P < 0.001$), and the Wilcoxon signed-rank test produced the same substantive conclusion (V = 0, $P < 0.001$). The effect size was large (Cohen's dz = 3.27). Although the standardized within-subject effect sizes were large, they should be interpreted as descriptive indicators of pre–post change rather than as evidence of exclusive causal impact, because the study did not include a non-exposed comparison group.

Table 5. Changes in knowledge and adoption scores before and after the microlearning intervention.

Indicator	Knowledge score (0–20)	Adoption score (0–6)
Pre mean ± SD	8.56 ± 2.92	2.15 ± 1.17
Post mean ± SD	16.02 ± 3.21	4.20 ± 1.41
Mean difference	7.46	2.05
95 % CI	7.26–7.66	1.97–2.14
t (df = 499)	73.23	47.65
p	<0.001	<0.001
Cohen's dz	3.27	2.13
Shapiro–Wilk W (p)	0.982 (<0.001)	0.900 (<0.001)
Wilcoxon V (p)	0 (<0.001)	0 (<0.001)

The composite adoption score increased from 2.15 ± 1.17 to 4.20 ± 1.41 out of 6. The mean change was 2.05 practices (95 % CI: 1.97–2.14), with a significant paired t-test (t = 47.65, df = 499, $P < 0.001$) and a significant Wilcoxon signed-rank test (V = 0, $P < 0.001$). The effect size was similarly large (Cohen's dz = 2.13), and the same interpretive caution applies. Because Shapiro–Wilk tests indicated non-normality of paired differences, the Wilcoxon results are reported as robustness checks.

Table 6. Distribution of farmers by knowledge level before and after intervention.

Knowledge level	Pre n (%)	Post n (%)
Low (0–7)	186 (37.2%)	3 (0.6%)
Medium (8–13)	290 (58.0%)	116 (23.2%)
High (14–20)	24 (4.8%)	381 (76.2%)

The Low/Medium/High knowledge-level categories were created as descriptive classifications for this study, dividing the 0–20 score range into approximately equal bands; they are not externally validated diagnostic thresholds and should not be interpreted as clinically or educationally established cut-points.

Practice-wise adoption: Practice-wise adoption increased across all six indicators. The largest absolute changes were observed in improved ripening practices, harvest tool use, plastic crate/proper packaging and de-sapping/cleaning. The discordant-pair pattern indicates that many more farmers moved from non-adoption to adoption than from adoption to non-adoption for each practice.

Demographic correlates and adjusted post-test model: Spearman correlations suggested no meaningful association between knowledge gain and age, years of schooling or landholding. In the adjusted regression model, post-test

Table 7. Practice-wise adoption changes with McNemar discordant-pair counts and Holm-adjusted p values

Practice	Pre adopted n (%)	Post adopted n (%)	No→Yes	Yes→No	McNemar χ^2	Raw p	Holm-adjusted p
Harvest tool use	174 (34.8%)	363 (72.6%)	225	36	135.42	<0.001	<0.001
Field sorting/grading	196 (39.2%)	336 (67.2%)	179	39	88.63	<0.001	<0.001
Plastic crates/proper packaging	176 (35.2%)	352 (70.4%)	208	32	127.60	<0.001	<0.001
Fungicidal dip / hot-water treatment	183 (36.6%)	342 (68.4%)	191	32	111.95	<0.001	<0.001
Improved ripening (ethylene/safe methods)	180 (36.0%)	368 (73.6%)	220	32	138.77	<0.001	<0.001
De-sapping and cleaning	166 (33.2%)	341 (68.2%)	206	31	127.75	<0.001	<0.001

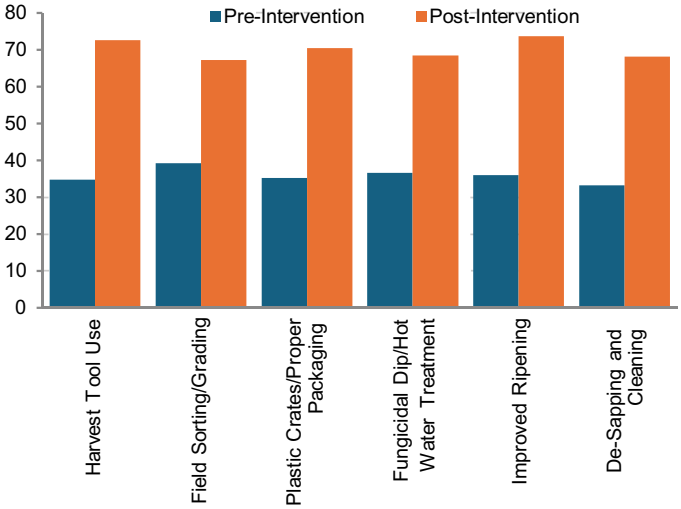

Fig. 1. Practice-wise adoption before and after the YouTube microlearning intervention.

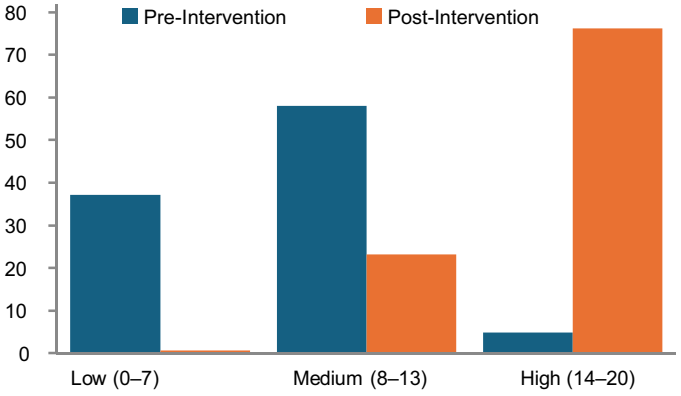

Fig. 2. Knowledge level distribution before and after the intervention.

knowledge was the dependent variable and baseline knowledge was entered as a covariate along with age, years of schooling and total landholding. Baseline knowledge was positively associated with post-test knowledge (β = 0.801, HC3 SE = 0.030, $P < 0.001$). Age, schooling and landholding were not statistically significant predictors after adjustment. The model explained 53.1 % of the variance in post-test knowledge (adjusted $R^2 = 0.528$). This model describes adjusted associations within the observed sample and does not support causal attribution without a comparison group.

Table 8. Multiple linear regression predicting post-test knowledge, adjusted for baseline knowledge. HC3 robust standard errors reported. Model fit: $R^2 = 0.531$; adjusted $R^2 = 0.528$.

Predictor	β (unstd.)	HC3 robust SE	t	p	95% CI
Age (years)	-0.006	0.008	-0.72	0.475	-0.023 to 0.011
Years of schooling	0.021	0.026	0.80	0.424	-0.030 to 0.071
Total landholding (acres)	0.022	0.055	0.40	0.693	-0.086 to 0.130
Baseline knowledge score	0.801	0.030	26.74	<0.001	0.742 to 0.860
Constant	9.189	0.547	16.81	<0.001	8.114 to 10.263

Table 9. Spearman correlations between selected farmer characteristics and knowledge gain.

Predictor	Spearman ρ with knowledge gain	p
Age (years)	-0.038	0.395
Years of schooling	0.032	0.480
Total landholding (acres)	-0.018	0.684

Discussion

The study found substantial pre–post increases in postharvest knowledge and self-reported adoption scores among mango farmers exposed to the Marathi-language YouTube microlearning series. The direction and magnitude of change suggest that short, locally contextualized instructional videos can be a useful extension complement during harvest windows. The visual and repeatable nature of the videos may have helped farmers understand operational steps that are difficult to communicate through text-based instruction alone, such as de-sapping, sorting/grading, safe handling and improved ripening. The observed increase in knowledge is broadly consistent with agricultural video-extension research showing that visual demonstration and repeated access can support procedural learning, particularly where extension messages involve sequential practices (Bentley *et al.*, 2014; Bentley *et al.*, 2019). However, the magnitude of change reported here should not be directly compared with controlled-trial effect sizes, because the present study lacked a comparison group and relied on repeated administration of the same knowledge instrument to the same respondents. The uneven exposure pattern observed in engagement (Table 4) also resembles findings from mobile- and chat-based agricultural extension research, where device access, digital confidence and peer mediation shape whether farmers engage with advisory content at all (Coggins *et al.*, 2024; Rajkhowa and Qaim, 2021). Read together, the present findings support the feasibility of assisted and peer-shared video delivery as a low-cost extension channel, but they do not establish universal reach or independently verified adoption, and self-reported practice change should be distinguished from objectively verified adoption reported in other digital-advisory evaluations.

The practice-wise adoption results provide a more nuanced interpretation than the composite adoption score alone. Adoption increased for all six practices, but the underlying friction may differ across practices. Low-cost and labour-dominant practices, such as sorting/grading, de-sapping and safer handling, may be adopted more readily when farmers understand their importance. Input-dependent practices, such as disease-management treatment or controlled ripening, may require not only knowledge but also

access to equipment, approved inputs, finance, market incentives and clear safety guidance. Therefore, digital microlearning should be integrated with input access, farmer-producer organisation support and field-level technical assistance.

Engagement data support the practical feasibility of the approach but also caution against assuming uniform exposure. Although 68.0 % of farmers reported watching at least six videos, 15.2 % watched only 0–2 videos. This variation is important because digital extension interventions can reproduce inequalities if farmers with weaker connectivity, lower digital confidence or limited device access receive less exposure. Assisted viewing, WhatsApp-based sharing and local facilitation may therefore remain necessary, especially for farmers with low digital literacy.

The adjusted regression model indicated that age, schooling and landholding were not statistically significant predictors of post-test knowledge after accounting for baseline knowledge. Baseline knowledge was positively associated with post-test knowledge, and the model explained a substantial proportion of post-test variance. This adjusted model avoids the mathematical coupling created when a gain score is regressed on its own baseline component. Nevertheless, the coefficient represents an observational association rather than an intervention effect because the study did not include a non-exposed comparison group. Future studies should include additional explanatory variables such as farmer-group membership, input access, market orientation, prior extension contact, verified video-completion data and objective field verification of practices, and should account for village-level clustering where reliable identifiers are available.

The horticultural credibility of such interventions depends on technical accuracy and regulatory caution. Recommendations involving fungicides, postharvest dips, hot-water treatment, storage and ripening must be aligned with current local approvals, residue limits, buyer requirements and export-market restrictions. Accordingly, chemical-treatment and ripening recommendations are framed cautiously, and all treatments should follow approved labels and applicable food-safety regulations. This is particularly important because calcium carbide is prohibited for artificial ripening in India, while ethylene-based ripening is permitted only under controlled and compliant conditions (FSSAI, 2020; FSSAI, 2025).

Limitations and future research: This study has several limitations. First, the one-group pre-test/post-test design does not permit strong causal attribution because it included no untreated or non-exposed comparison group. Second, purposive sampling limits generalisability beyond digitally reachable mango farmers in the Konkan region. Third, adoption was measured primarily through farmer self-report, which may be affected by recall bias and social-desirability bias. Fourth, the follow-up period was limited to the same harvest season, and the study did not directly measure postharvest loss reduction, fruit quality improvement, price realisation or income change. Fifth, platform-level engagement data such as click-through rate, retention curves and verified watch time were not fully retained. Sixth, the temporary unavailability of the original video links after the intervention limits long-term access and sustainability unless the videos are archived. Finally, farmer-to-farmer sharing may have created contamination effects, although such sharing is also an important real-world feature of digital extension diffusion. In addition, the original instrument combined fungicidal dip with hot-water treatment, and combined controlled ethylene ripening with avoidance of calcium carbide, into two single indicators; because the retained dataset did not permit retrospective disaggregation, these were analysed as broad composite indicators and should not be interpreted as technically equivalent practices. The analysis also did not adjust for possible within-village correlation because complete and consistently coded village identifiers were not available for all respondents, so standard errors may be underestimated.

Future research should use controlled or cluster-randomised designs, longer follow-up periods and objective verification of adoption through field observation, photographs or packhouse records. Future studies should also measure fruit-quality outcomes, postharvest loss reduction, market price realisation and cost-effectiveness. Platform analytics should be systematically archived so that exposure can be linked more precisely with learning and adoption outcomes.

The findings suggest that locally contextualised YouTube microlearning may complement conventional horticultural extension by improving postharvest knowledge and encouraging reported adoption of recommended practices among mango farmers. Significant pre–post gains were observed in knowledge and self-reported adoption scores; however, because the study lacked a non-exposed comparison group, these changes should be interpreted cautiously. The intervention appears especially suitable as a low-cost reinforcement mechanism during time-sensitive harvest windows, provided that technical recommendations are validated, regulatory caution is maintained, and digitally less confident farmers receive support. Future controlled studies should verify adoption through field observation and assess whether such digital extension interventions reduce postharvest losses, improve fruit quality and enhance farmer income.

Safety and regulatory note: Implement all chemical treatments and ripening recommendations only in accordance with current locally approved labels, residue limits, buyer specifications and export-market requirements. Farmers should not use calcium carbide or any other prohibited ripening agent. Postharvest fungicide and hot-water treatment recommendations must be validated against current Indian regulations and market-specific requirements before large-scale extension use.

Ethics approval and consent to participate: Formal institutional ethics review was not obtained before data collection. Participation was voluntary, informed consent was obtained, and no identifying information is reported. This absence of prospective ethics review is acknowledged as a limitation of this study.

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