Natural Resources for Human Health
eISSN: 2583-1194

Original Research

Received 07 May 2026
Revised 25 June 2026
Accepted 07 July 2026

Natural Resources for Human Health 2026, Vol. 6 (11s): 52–67

KEYWORDS:
sous vide; food safety; consumer literacy; knowledge–practice pathway; self-efficacy; ready-to-eat foods; reduced-oxygen packaging

Consumer Food-Safety Literacy in Sous-Vide Practices: From Knowledge Deficits to Safety Behaviour

Gayathri Balachandran[1], Dr. Pritha Chaturvedi[2]

[1]PhD Scholar, Faculty of Management Studies, ICFAI University Jharkhand, India
E-mail: gayathrib2006@gmail.com
[2]Assistant Professor, Faculty of Management Studies, ICFAI University Jharkhand, India, E-mail: prithachaturvedi@iujharkhand.edu.in

ABSTRACT: Sous-vide preparation and ready-to-eat foods depend on controlled time–temperature processing, appropriate packaging, rapid chilling where required, refrigeration, storage, and handling. Consumer safety therefore depends not only on factual knowledge but also on the ability and confidence to apply food-safety information in practical situations. This study examined the relationships among sous-vide food-safety knowledge (SVK), applied food-safety literacy (AFSL), safety self-efficacy (SSE), safe sous-vide practice (SSP), and potentially unsafe and non-recommended sous-vide practices (PUNSP). A structured cross-sectional survey of 400 respondents from Andhra Pradesh and Telangana was analysed using descriptive statistics, reliability analysis, Pearson correlations, multiple regression, and bootstrap mediation analysis. SVK was positively associated with AFSL ($r = .439$), and AFSL was positively associated with both SSE ($r = .555$) and SSP ($r = .578$). In the regression models, AFSL and SSE were significant positive predictors of SSP, whereas SVK was not significant after adjustment for the other predictors. The indirect association between SVK and SSP through AFSL was statistically supported (indirect effect = 0.0535, 95% bootstrap CI [0.0353, 0.0736]). Potentially unsafe and non-recommended practices were strongly inversely associated with safe practice. The findings indicate that food-safety knowledge and its practical application are related but distinct dimensions of consumer food-safety competence. The results support consumer education that emphasises scenario-based interpretation, validated time–temperature controls, packaging suitability, chilling, refrigeration, storage, and reheating rather than relying on general awareness alone.

1.0 INTRODUCTION

Sous vide is a controlled cooking and food-processing approach in which food is commonly placed in a sealed or vacuum-oriented package and heated under controlled time–temperature conditions. The method is used in professional food service, ready-meal production, and household cooking because it can provide reproducible processing and quality outcomes. Its safety, however, depends on appropriate thermal processing and control of post-processing conditions.

The U.S. Food and Drug Administration (FDA, 2022) includes sous vide within reduced-oxygen packaging (ROP) and describes cook-chill sous vide as food placed in an impermeable bag, cooked in the bag, rapidly chilled, and refrigerated under conditions intended to inhibit relevant psychrotrophic pathogens. ROP can reduce aerobic spoilage, but inadequate controls may create conditions favourable to certain pathogens, making process control essential (U.S. Food and Drug Administration [FDA], 2022).

Recent reviews identify precision, quality retention, and broad application as advantages of sous vide while also emphasising microbial-safety limitations and the importance of appropriate processing conditions and training (Misu et al., 2024; Onyeaka

et al., 2022). Research on commercially produced sous-vide ready meals has likewise demonstrated the importance of controlled storage temperature, with temperature abuse associated with increased bacterial counts (Nissen et al., 2002).

Consumer food safety in sous vide therefore involves a chain of decisions rather than a single cooking-temperature decision. Relevant behaviours include following validated instructions, using suitable packaging, checking pouch integrity, controlling the cooking process, rapidly chilling cooked food when required, maintaining refrigeration, observing storage limits, and reheating or serving according to applicable instructions.

Packaging adds another food-safety dimension. Chemical migration from food-contact materials is influenced by temperature, contact time, food composition, material characteristics, and other conditions of use (Gupta et al., 2024; Panou & Karabagias, 2024; Seref & Cufaoglu, 2025; Zhang et al., 2025). These findings do not imply that all heated plastic packaging is unsafe. Rather, they support the importance of selecting and using food-contact materials under conditions for which they are intended.

The consumer-side knowledge–behaviour pathway remains comparatively underexplored in the sous-vide context. Consumers may recognise that sous vide uses lower temperatures yet incorrectly infer that any lower temperature is safer. They may understand refrigeration generally but fail to recognise that vacuum packaging does not make cooked food shelf-stable. They may also interpret a general food-grade claim as evidence that any pouch is suitable for prolonged heating.

To address this gap, the present study distinguishes objective knowledge from applied food-safety literacy and safety self-efficacy. The framework proposes that factual knowledge is related to the ability to interpret and apply safety information, which is in turn related to confidence and reported safety behaviour. Potentially unsafe and non-recommended practices are measured separately to identify specific behavioural vulnerabilities.

2.0 REVIEW OF LITERATURE

2.1 Sous Vide and Microbial Safety

Sous vide combines controlled heating with reduced-oxygen packaging. The FDA Food Code treats sous vide as an ROP process and specifies controls for cook-chill applications (FDA, 2022). The technical literature indicates that safety depends on the actual time–temperature process, food matrix, storage conditions, and handling procedures rather than on the cooking label alone (Misu et al., 2024; Onyeaka et al., 2022; Romeo et al., 2024).

2.2 Storage and Temperature Abuse

Post-cooking handling is particularly important for ready-to-eat products. Nissen et al. (2002) found that controlled cold storage was associated with limited bacterial growth in sous-vide ready meals, whereas storage under temperature-abuse conditions produced substantially greater bacterial increases. This evidence supports measuring cooling, refrigeration, transport, and storage behaviour alongside cooking knowledge.

2.3 Packaging and Chemical Migration

Food packaging can interact with food through migration, sorption, permeation, and related mechanisms. Migration is influenced by temperature, contact time, food composition, surface area, and material properties (Gupta et al., 2024; Panou & Karabagias, 2024; Seref & Cufaoglu, 2025; Zhang et al., 2025). For consumer research, the relevant construct is packaging literacy: whether consumers understand that a food-contact material must be appropriate for the intended food, temperature, and duration of contact.

2.4 Knowledge–Practice Gap

Knowledge is an important prerequisite for safe behaviour, but knowledge alone does not guarantee implementation. Consumer food-safety research distinguishes awareness of hazards from actual food-handling behaviour. The present study extends this reasoning by measuring applied literacy separately from objective knowledge.

2.5 Self-Efficacy and Food-Safety Behaviour

Social cognitive theory proposes that self-efficacy influences behavioural initiation, persistence, and self-regulation (Bandura, 1986, 1997). In the present context, consumers may know an appropriate safety procedure but fail to implement it if they lack confidence in temperature monitoring, chilling, packaging selection, or storage decisions.

3.0 THEORETICAL FOUNDATION

The framework integrates social cognitive theory, health literacy, and knowledge–practice reasoning. Social cognitive theory provides the theoretical basis for safety self-efficacy (Bandura, 1986, 1997). Health literacy distinguishes the capacity to access, understand, appraise, and use information in decisions (Nutbeam, 2000). Knowledge–practice reasoning provides the overall pathway from factual understanding to behavioural implementation. Accordingly, SVK is conceptualised as factual knowledge; AFSL as the ability to interpret and apply food-safety information; SSE as perceived capability to perform safety actions; SSP as reported safe behaviour; and PUNSP as a complementary measure of potentially unsafe and non-recommended behaviour. The constructs are treated as related but empirically distinct dimensions of consumer food-safety competence.

4.0 CONCEPTUAL FRAMEWORK

The conceptual framework examines how consumers' sous-vide food-safety knowledge is associated with reported food-safety practices. The framework assumes that knowing food-safety principles is important but may not be sufficient for safe behaviour. Consumers must also be able to interpret and apply food-safety information to practical sous-vide situations and feel capable of carrying out the required safety actions. Sous-Vide Food-Safety Knowledge (SVK) represents objective understanding of relevant safety principles. Applied Food-Safety Literacy (AFSL) represents the ability to interpret and apply food-safety information when making decisions about sous-vide preparation, packaging, chilling, refrigeration, and storage. Safety Self-Efficacy (SSE) represents confidence in carrying out appropriate safety actions. Safe Sous-Vide Practice (SSP) represents reported adherence to recommended practices. The framework also includes authoritative food-safety information exposure as a contextual factor that may be associated with applied literacy. Previous sous-vide experience is retained as contextual information because experience may shape knowledge and behavioural responses, although it was not included as a predictor in the reported regression models. Potentially Unsafe and Non-Recommended Sous-Vide Practices (PUNSP) are examined separately. These behaviours include guessing cooking conditions, relying on appearance rather than validated instructions, disregarding recommended storage requirements, assuming that vacuum packaging eliminates the need for refrigeration, and using packaging without checking its suitability for the intended heating conditions. PUNSP is expected to be inversely associated with SSP.

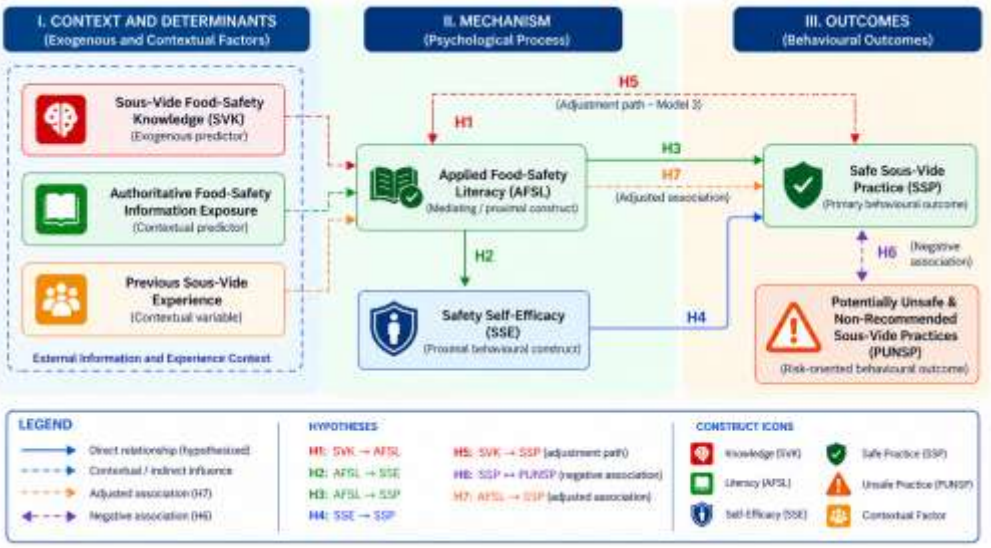

Figure 1. Conceptual framework of consumer food-safety knowledge, literacy, self-efficacy, and sous-vide safety practices.

Table 1. Operationalization of Constructs and Their Roles in the Conceptual Framework

Construct	Role	Operational definition
SVK	Exogenous predictor	Correct responses to 10 objective knowledge items; score

		range 0–10.
AFSL	Proposed mediator / proximal construct	Ability to interpret and apply food-safety information to practical sous-vide situations; mean of five items.
SSE	Proximal behavioural construct	Confidence in carrying out relevant food-safety actions; mean of four items.
SSP	Primary behavioural outcome	Frequency of reported safe sous-vide practices; mean of eight items.
PUNSP	Risk-oriented behavioural outcome	Frequency of potentially unsafe and non-recommended practices; mean of ten items.
Authoritative information exposure	Contextual predictor	Self-reported frequency of exposure to authoritative food-safety information.
Previous sous-vide experience	Contextual variable	Self-reported previous experience with sous-vide cooking.

5.0 HYPOTHESES

H1 Higher sous-vide food-safety knowledge is positively associated with applied food-safety literacy.
H2 Higher applied food-safety literacy is positively associated with safety self-efficacy.
H3 Higher applied food-safety literacy is positively associated with safe sous-vide practice.
H4 Higher safety self-efficacy is positively associated with safe sous-vide practice.
H5 Sous-vide food-safety knowledge is indirectly associated with safe sous-vide practice through applied food-safety literacy.
H6 More frequent potentially unsafe and non-recommended sous-vide practices are negatively associated with safe sous-vide practice.
H7 Applied food-safety literacy remains positively associated with safe sous-vide practice after adjustment for objective knowledge, safety self-efficacy, and authoritative food-safety information exposure.

6.0 METHODOLOGY

This study employed a quantitative, cross-sectional survey design to examine the relationships among consumer sous-vide food-safety knowledge, applied food-safety literacy, safety self-efficacy, and reported food-safety practices. The empirical dataset comprised 400 respondents from Andhra Pradesh and Telangana.

6.1 Research Design

A quantitative cross-sectional survey was used to investigate consumer food-safety literacy and behaviour associated with sous-vide and related ready-to-eat or heat-and-eat foods. The design enabled examination of associations among knowledge, literacy, self-efficacy, and reported practice at a single point in time.

6.2 Population and Sampling

A stratified sampling approach was used, with state of residence defining the two geographic strata: Telangana and Andhra Pradesh. The final sample comprised 215 respondents from Telangana (53.8%) and 185 respondents from Andhra Pradesh (46.3%), giving a total of 400 respondents. The sample included respondents with varying levels of previous sous-vide experience, including respondents who reported no previous experience.

6.3 Research Instrument

The questionnaire comprised demographic and contextual variables, objective knowledge items, applied literacy items, safety self-efficacy items, safe-practice items, and potentially unsafe and non-recommended practice items. The instrument was structured to capture both factual knowledge and the ability to apply food-safety information to practical sous-vide situations.

6.4 Measurement

SVK was measured using 10 objective items scored as correct or incorrect, producing a total score from 0 to 10. AFSL comprised five items measured on a five-point agreement scale. SSE comprised four five-point agreement items. SSP comprised eight five-point frequency items, and PUNSP comprised ten five-point frequency items. Higher SSP scores indicate more frequent safe practices, whereas higher PUNSP scores indicate more frequent potentially unsafe or non-recommended practices.

Table 2. Measurement and Scoring of Study Constructs

Construct	Items	Scale	Scoring
SVK	10	True / False / Don't know	Sum of correct responses; 0–10
AFSL	5	5-point Likert	Mean; 1–5
SSE	4	5-point Likert	Mean; 1–5
SSP	8	5-point frequency	Mean; 1–5
PUNSP	10	5-point frequency	Mean; 1–5

6.5 Statistical Analysis

Data were analysed using descriptive statistics, internal-consistency assessment, Pearson correlation analysis, multiple regression, and bootstrap mediation analysis. Multiple regression models were used to examine the predictive relationships specified in the framework. The mediation analysis evaluated the indirect association SVK → AFSL → SSP using 5,000 bootstrap resamples and a percentile bootstrap 95% confidence interval**.** Statistical significance was evaluated at the 5% level.

6.6 Ethical Considerations

Participation in the survey was voluntary. Respondents were informed of the academic purpose of the study, and the information collected was used solely for research purposes. Data were analysed and reported objectively, with due care to avoid fabrication, falsification, manipulation, or misrepresentation of findings. No personally identifying information was reported in the study.

6.7 Research Gap

The study addresses a consumer-level gap by integrating factual knowledge, applied literacy, self-efficacy, and reported practice. It also considers exposure to authoritative food-safety information and previous experience as contextual variables. This framework distinguishes several possible points at which food-safety information may fail to translate into behaviour: limited knowledge, difficulty applying knowledge, low confidence, or specific behavioural habits.

Existing literature provides substantial technical knowledge about sous vide processing, microbial inactivation, food quality, and packaging interactions, but comparatively less consumer research integrates these dimensions into a single behavioural framework. Technical studies establish the importance of process controls, whereas consumers interact directly with instructions, packaging, refrigeration equipment, storage environments, and reheating practices. A consumer-centred framework therefore complements process-validation research by examining whether people understand and implement the controls that technical evidence requires.

6.8 Why Unsafe and Non-Recommended Practices Should Be Measured Separately

The study does not assume that every deviation from a recommended practice produces illness. Instead, the instrument identifies behaviours that depart from validated or authoritative food-safety guidance. This distinction is important when communicating about packaging and chemical migration, because risk depends on exposure conditions and the properties and intended use of the specific material (Gupta et al., 2024; Seref & Cufaoglu, 2025).

A composite safe-practice score can conceal specific behaviours with different risk implications. Measuring potentially unsafe and non-recommended practices separately permits identification of decision points such as guessing temperatures, relying on appearance rather than validated instructions, failing to chill cooked products appropriately, assuming vacuum packaging eliminates the need for refrigeration, or using packaging without checking its intended heating suitability.

6.9 Packaging Literacy and Heating Suitability

The relevant consumer question is not whether plastic is inherently safe or unsafe. Instead, the relevant question is whether a food-contact material is appropriate for the intended conditions of use. A pouch suitable for refrigerated storage is not automatically suitable for prolonged heating, and a generic food-grade claim does not communicate every condition of use. Packaging literacy therefore provides a scientifically defensible way to incorporate consumer understanding of packaging into the study without making unsupported claims about exposure or disease.

Packaging literacy is particularly relevant to sous vide because food may remain in direct contact with the pouch during prolonged heating. Scientific reviews demonstrate that migration is influenced by material characteristics and conditions of use, including temperature, contact time, food composition, and storage conditions (Gupta et al., 2024; Panou & Karabagias, 2024; Seref & Cufaoglu, 2025; Zhang et al., 2025).

6.10 Distinguishing Safety Knowledge from Applied Literacy

Applied food-safety literacy is conceptualised as the capability to interpret instructions, recognise relevant conditions, identify when a practice is unsafe or non-recommended, and select an appropriate response. This distinction is consistent with health-literacy theory, in which understanding information is not identical to using that information to make decisions (Nutbeam, 2000).

A central contribution of the framework is therefore the distinction between knowing a food-safety fact and applying that fact to a practical situation. A respondent may correctly state that cooked food should be refrigerated but fail to recognise that a vacuum-packed cooked product left at room temperature for an extended period requires corrective action. Similarly, a respondent may know that temperature matters but still select a cooking condition because it appears low and gentle rather than because it is validated for the specific food.

6.11 Food-Safety Risk Domains Relevant to Consumer Practice

The food-safety risks associated with sous vide extend beyond the cooking step and involve interconnected control points from preparation to consumption. The consumer-facing chain includes raw-material hygiene, thermal processing, packaging integrity, post-cooking cooling, refrigeration, storage and transport, and reheating or serving. Thermal time–temperature control is a central domain. Sous-vide processing commonly uses lower cooking temperatures for longer periods than conventional high-temperature cooking; therefore, safety cannot be judged solely by visual appearance. The combination of temperature and time must be appropriate for the food being prepared, while factors such as food thickness, composition, initial microbial load, and equipment performance can influence process effectiveness (Misu et al., 2024; Onyeaka et al., 2022; Romeo et al., 2024). Packaging suitability and integrity represent another important domain. Consumers may incorrectly assume that any plastic or food-contact bag is suitable for prolonged heating. Food-contact suitability and suitability for a particular heating application are not necessarily equivalent. Appropriate packaging should therefore be selected for the intended temperature, food, and duration of contact. Post-cooking cooling and refrigeration are particularly important when sous-vide foods are prepared for later consumption. Vacuum or reduced-oxygen packaging does not eliminate the need for temperature control. Extended exposure to unsuitable storage temperatures can undermine safety controls achieved during processing (FDA, 2022; Nissen et al., 2002). Handling, reheating, and serving form the final stages of the consumer food-safety chain. Opening, puncturing, transferring, or otherwise handling a pouch can create opportunities for contamination. Reheating or serving without following applicable product or validated instructions may also undermine established controls. These domains justify examining food-safety knowledge together with the ability to apply information in practical situations.

7.0 RESULTS

7.1 Participant Profile

The study included 400 respondents from Andhra Pradesh and Telangana. The sample comprised 222 females (55.5%), 169 males (42.3%), and 9 respondents (2.3%) who identified as other or preferred not to say. Educational attainment included 187

undergraduates (46.8%), 123 postgraduates (30.8%), 49 respondents with higher-secondary education (12.3%), and 41 respondents with doctoral or professional qualifications (10.3%). Professionals represented 36.8% of the sample, followed by students (28.5%), business/self-employed respondents (16.5%), homemakers (10.8%), and respondents in other occupational categories (7.5%). The regional distribution comprised 215 respondents (53.8%) from Telangana and 185 (46.3%) from Andhra Pradesh. Previous sous-vide experience varied: 143 respondents (35.8%) reported no previous experience, 115 (28.8%) had used sous vide one or two times, 69 (17.3%) had used it three to five times, and 73 (18.3%) reported more than five occasions of use.

Table 3. Gender Distribution of Respondents

Gender	n	%
Female	222	55.5%
Male	169	42.3%
Other / Prefer not to say	9	2.3%

Table 4. Educational Profile of Respondents

Education	n	%
Undergraduate	187	46.8%
Postgraduate	123	30.8%
Higher secondary	49	12.3%
Doctoral / Professional	41	10.3%

Table 5. Occupational Profile of Respondents

Occupation	n	%
Professional	147	36.8%
Student	114	28.5%
Business / Self-employed	66	16.5%
Homemaker	43	10.8%
Other	30	7.5%

Table 6. Regional Distribution of Respondents

Region	n	%
Telangana	215	53.8%
Andhra Pradesh	185	46.3%

Table 7. Distribution of Respondents by Sous-Vide Experience

Sous-Vide Experience	n	%
Never	143	35.8%
1–2 times	115	28.8%
3–5 times	69	17.3%
>5 times	73	18.3%

7.2 Descriptive Statistics

The SVK score had a mean of 5.22 (SD = 2.51) on a 0–10 scale, indicating substantial variation in objective food-safety knowledge. AFSL had a mean of 3.00 (SD = 0.97), SSE had a mean of 2.98 (SD = 1.06), SSP had a mean of 2.98 (SD = 0.94), and PUNSP had a mean of 3.02 (SD = 0.61).

The descriptive findings indicate variability in objective knowledge and individual differences in applied food-safety literacy, confidence, and reported practices. These results provide an initial indication that factual knowledge and the ability to translate knowledge into practical behaviour are distinct dimensions.

Table 8. Descriptive Statistics of the Study Constructs

Measure	Mean	SD
SVK score (0–10)	5.22	2.51
AFSL	3.00	0.97
SSE	2.98	1.06
SSP	2.98	0.94
PUNSP	3.02	0.61

7.3 Reliability

Internal consistency reliability was assessed for the multi-item Likert-type constructs using Cronbach's alpha. AFSL demonstrated $\alpha = .840$, SSE $\alpha = .882$, SSP $\alpha = .900$, and PUNSP $\alpha = .750$. These coefficients indicate acceptable to good internal consistency for the reported multi-item constructs. SVK was measured as a summed objective knowledge score based on ten dichotomously scored items. Because item-level response data were not available in the analysis record used for this study, an item-level reliability coefficient (KR-20) could not be independently calculated or verified. Accordingly, no KR-20 value is reported.

Table 9. Internal Consistency Reliability of the Multi-Item Study Constructs

Construct	Cronbach's α
AFSL	.840
SSE	.882
SSP	.900
PUNSP	.750

7.4 Correlation Analysis

Pearson correlation analysis was conducted to examine relationships among objective knowledge, applied food-safety literacy, safety self-efficacy, safe practice, and potentially unsafe/non-recommended practice. SVK was positively correlated with AFSL ($r = .439$), SSE ($r = .287$), and SSP ($r = .290$), and negatively correlated with PUNSP ($r = -.242$).

AFSL was positively correlated with SSE ($r = .555$) and SSP ($r = .578$), and negatively correlated with PUNSP ($r = -.420$). SSE was positively correlated with SSP ($r = .621$) and negatively correlated with PUNSP ($r = -.431$). The strongest reported association was the inverse relationship between SSP and PUNSP ($r = -.685$).

These results provide bivariate support for the proposed relationships. Because the data are cross-sectional and self-reported, the correlations should be interpreted as associations rather than evidence of causality.

Table 10. Pearson Correlations among Study Constructs

Variable 1	Variable 2	Pearson r
SVK	AFSL	.439
SVK	SSE	.287
SVK	SSP	.290
SVK	PUNSP	−.242
AFSL	SSE	.555
AFSL	SSP	.578
AFSL	PUNSP	−.420
SSE	SSP	.621
SSE	PUNSP	−.431
SSP	PUNSP	−.685

7.5 Regression Analysis

Four multiple regression models were estimated. Model 1 examined SVK as a predictor of AFSL; Model 2 examined AFSL as a predictor of SSE; Model 3 examined SSP using AFSL, SSE, SVK, and authoritative information exposure as predictors; and Model 4 examined SSP using PUNSP, AFSL, SSE, and SVK as predictors.

Model 1: Objective Knowledge and Applied Food-Safety Literacy

Model 1 was statistically significant, $R^2 = .193$, $F(1, 398) = 95.14$, $p < .001$, indicating that SVK accounted for approximately 19.3% of the variance in AFSL. SVK was positively associated with AFSL ($B = .171$, $SE = .017$, $p < .001$).

Model 2: Applied Food-Safety Literacy and Safety Self-Efficacy

Model 2 was statistically significant, $R^2 = .308$, $F(1, 398) = 176.79$, $p < .001$, and AFSL was positively associated with SSE ($B = .603$, $SE = .045$, $p < .001$). AFSL therefore accounted for a substantial proportion of the variance in reported safety self-efficacy.

Model 3: Predictors of Safe Sous-Vide Practice

Model 3 was statistically significant, $R^2 = .465$, $F(4, 395) = 85.91$, $p < .001$, explaining 46.5% of the variance in SSP. AFSL was a significant positive predictor of SSP ($B = .315$, $SE = .046$, $p < .001$), as was SSE ($B = .384$, $SE = .040$, $p < .001$). SVK was not significant after adjustment for the other predictors ($B = .008$, $SE = .016$, $p = .628$), and authoritative information exposure was also not significant ($B = .012$, $SE = .036$, $p = .731$).

The positive bivariate relationship between SVK and SSP was therefore attenuated to non-significance when AFSL, SSE, and information exposure were included simultaneously. This pattern is consistent with the study's distinction between factual knowledge and the practical application of knowledge, although the cross-sectional design does not establish a causal sequence.

Model 4: Predictors of Safe Sous-Vide Practice Including PUNSP

Model 4 was statistically significant, $R^2 = .630$, $F(4, 395) = 167.92$, $p < .001$, explaining 63.0% of the variance in SSP. PUNSP was negatively associated with SSP ($B = −.715$, $SE = .054$, $p < .001$). AFSL ($B = .210$, $SE = .039$, $p < .001$) and SSE ($B = .269$, $SE = .034$, $p < .001$) were positive predictors, whereas SVK was not statistically significant ($B = −.002$, $SE = .013$, $p = .904$).

The strong inverse association between SSP and PUNSP indicates that respondents reporting more frequent safe behaviours also tended to report fewer potentially unsafe or non-recommended behaviours. Because both measures were self-reported and behaviourally related, this result should be interpreted as an association rather than evidence that one type of behaviour causes the other.

Table 11. Summary of Multiple Regression Models

Model	Outcome	Predictors	R^2	F	p
M1	AFSL	SVK	.193	95.14	< .001
M2	SSE	AFSL	.308	176.79	< .001
M3	SSP	AFSL, SSE, SVK, Information Exposure	.465	85.91	< .001
M4	SSP	PUNSP, AFSL, SSE, SVK	.630	167.92	< .001

Table 12. Regression Coefficients for the Multiple Regression Models

Model	Predictor	B	SE	p
M1	SVK	.171	.017	< .001
M2	AFSL	.603	.045	< .001
M3	AFSL	.315	.046	< .001
M3	SSE	.384	.040	< .001
M3	SVK	.008	.016	.628
M3	Authoritative information exposure	.012	.036	.731
M4	PUNSP	−.715	.054	< .001
M4	SVK	−.002	.013	.904
M4	AFSL	.210	.039	< .001
M4	SSE	.269	.034	< .001

7.6 Summary of Hypothesis Testing

The reported analyses support H1, H2, H3, H4, H5, H6, and H7. H6 is supported by the reported negative association between potentially unsafe and non-recommended practices and safe sous-vide practice. H7 is supported because applied food-safety literacy remains a significant positive predictor of safe sous-vide practice after adjustment for objective knowledge, safety self-efficacy, and authoritative food-safety information exposure.

Table 13. Hypothesis Testing Summary

Hypothesis	Result	Evidence
H1	Supported	SVK → AFSL: B = .171, p < .001; r = .439
H2	Supported	AFSL → SSE: B = .603, p < .001; r = .555
H3	Supported	AFSL → SSP: B = .315, p < .001; r = .578
H4	Supported	SSE → SSP: B = .384, p < .001; r = .621
H5	Supported	Indirect effect = .0535; 95% bootstrap CI [.0353, .0736]
H6	Supported	PUNSP → SSP: B = −.715, p < .001; r = −.685
H7	Supported	AFSL remains significant in M3 after adjustment: B = .315, p < .001

7.7 Mediation Analysis

A mediation analysis was conducted to examine whether Applied Food-Safety Literacy (AFSL) statistically mediated the association between Sous-Vide Food-Safety Knowledge (SVK) and Safe Sous-Vide Practice (SSP). The indirect pathway tested was SVK → AFSL → SSP. The estimated indirect effect was **0.0535**, with a **percentile bootstrap 95% confidence interval of [0.0353, 0.0736] based on 5,000 bootstrap resamples**. Because the confidence interval did not include zero, the indirect effect was statistically significant.

These findings indicate that SVK was statistically associated with SSP through AFSL. However, the available mediation results do not provide estimates and confidence intervals for the direct and total effects. Therefore, the findings are reported as a **statistically significant indirect association** rather than as evidence of full or partial mediation. Furthermore, given the cross-sectional design, the mediation analysis does not establish a causal sequence among knowledge, literacy, and safe practice. The results should therefore be interpreted as evidence of an indirect statistical association rather than a causal mediation mechanism.

8.0 DISCUSSION

The findings support a distinction between objective food-safety knowledge and the ability to apply that knowledge to practical sous-vide decisions. SVK was positively associated with AFSL, while AFSL showed positive relationships with both SSE and SSP. In the multivariable model, AFSL and SSE remained significant predictors of SSP, whereas the direct coefficient for SVK was not significant. This pattern is consistent with the study's central proposition that factual knowledge and practical application represent related but distinct dimensions of consumer food-safety competence.

The role of safety self-efficacy is also consistent with social cognitive theory, which proposes that perceived capability influences behavioural initiation and persistence (Bandura, 1986, 1997). In the present data, SSE was positively associated with SSP and remained a significant predictor when AFSL, SVK, and information exposure were considered.

The mediation result provides additional support for an indirect knowledge–literacy–practice association. The bootstrap confidence interval for the indirect effect excluded zero. However, because the study is cross-sectional, the result should be interpreted as an indirect statistical association rather than evidence that knowledge causes literacy and literacy subsequently causes behaviour.

The packaging component should also be communicated carefully. Contemporary literature indicates that chemical migration depends on material characteristics and conditions of use, including temperature, contact time, food composition, and storage conditions (Gupta et al., 2024; Panou & Karabagias, 2024; Seref & Cufaoglu, 2025; Zhang et al., 2025). The appropriate consumer message is therefore that packaging should be suitable for its intended food-contact and heating conditions, not that all plastic packaging is hazardous.

The findings also highlight the importance of post-cooking handling. FDA guidance and published sous-vide research emphasise the need for appropriate reduced-oxygen packaging controls, cooling, and refrigerated storage (FDA, 2022; Nissen et al., 2002; Romeo et al., 2024). Consumer education that focuses only on cooking temperature may therefore overlook other important control points.

8.1 Theoretical Implications

The framework extends a simple knowledge–practice model by treating applied food-safety literacy and self-efficacy as distinct constructs. The empirical pattern indicates that both constructs are related to reported safe practice, while objective knowledge alone is not sufficient to explain SSP in the fully adjusted model.

8.2 Practical Implications

- Use scenario-based consumer education rather than general safety messages alone.
- Communicate validated heating, cooling, refrigeration, storage, and reheating requirements clearly.
- Encourage consumers to check packaging suitability for the intended heating and food-contact conditions.
- Clarify that vacuum packaging is not equivalent to shelf-stable packaging.
- Use authoritative food-safety sources when designing consumer information.

9.0 LIMITATIONS

- The sample comprised 400 respondents from Andhra Pradesh and Telangana; the findings should not be interpreted as population prevalence estimates for all Indian consumers.
- The cross-sectional design cannot establish temporal or causal relationships.
- Self-reported behaviour may be affected by recall and social-desirability bias.
- Consumer survey findings cannot substitute for microbiological testing or chemical-migration testing of specific packaging materials.

10.0 CONCLUSION

This study examined consumer food-safety knowledge, applied food-safety literacy, self-efficacy, and reported sous-vide practices using data from 400 respondents in Andhra Pradesh and Telangana. The results indicate that objective knowledge is positively associated with applied food-safety literacy, while applied literacy and safety self-efficacy show stronger relationships with reported safe practice in the multivariable analyses. The indirect association between knowledge and safe practice through applied literacy was statistically supported. Potentially unsafe and non-recommended practices were strongly inversely associated with safe practice.

The findings suggest that consumer food-safety communication should move beyond general awareness and address practical interpretation, confidence, validated time–temperature control, packaging suitability, chilling, refrigeration, storage, and reheating. The findings should nevertheless be interpreted within the limitations of the cross-sectional design and self-reported measures.

Appendix A. Survey Questionnaire

The questionnaire operationalizes the study constructs. The wording below reflects the instrument used in the study and is retained to provide transparency regarding the measurement basis of the reported analyses.

A1. Respondent and Context Information

Appendix Table A1. Respondent and Context Variables

Variable	Response / coding
Respondent_ID	Unique numeric identifier
Age	Age in completed years
Gender	Male / Female / Other / Prefer not to say
Education	School / Undergraduate / Postgraduate / Doctoral / Other
Occupation	Student / Homemaker / Salaried / Self-employed / Food-service / Other

Monthly_Household_Income	Categorical income bands as defined in the survey
Region	Respondent's residential region
Sous_Vide_Experience	Never / 1–2 times / 3–5 times / >5 times
Authoritative_Info_Exposure_1to5	1 = Never; 5 = Very frequently

A2. Sous-Vide Food-Safety Knowledge (SVK)

Appendix Table A2. SVK Items

Code	Question	Response / scoring
SVK1	Sous-vide cooking involves cooking food in a sealed or vacuum package under controlled time and temperature conditions.	True / False / Don't know; correct response = 1, incorrect or Don't know = 0.
SVK2	Vacuum packaging by itself makes cooked food shelf-stable at room temperature.	True / False / Don't know; correct response = 1, incorrect or Don't know = 0.
SVK3	The safety of sous-vide foods depends on controlling both time and temperature.	True / False / Don't know; correct response = 1, incorrect or Don't know = 0.
SVK4	Some pathogens of concern in reduced-oxygen packaged foods can grow at refrigeration temperatures.	True / False / Don't know; correct response = 1, incorrect or Don't know = 0.
SVK5	A validated time–temperature combination is more important for safety than simply judging whether food looks cooked.	True / False / Don't know; correct response = 1, incorrect or Don't know = 0.
SVK6	Rapid chilling and appropriate refrigerated storage can be important after cooking sous-vide foods intended for later consumption.	True / False / Don't know; correct response = 1, incorrect or Don't know = 0.
SVK7	A bag that is suitable for food contact is automatically suitable for every prolonged heating application.	True / False / Don't know; correct response = 1, incorrect or Don't know = 0.
SVK8	Damaged or poorly sealed pouches can create food-safety problems during handling and storage.	True / False / Don't know; correct response = 1, incorrect or Don't know = 0.
SVK9	The temperature of the water bath is always identical to the temperature at the coldest point inside the food.	True / False / Don't know; correct response = 1, incorrect or Don't know = 0.
SVK10	Manufacturer or validated instructions should be followed when a commercial sous-vide/ready-to-eat product specifies cooking, chilling, or storage conditions.	True / False / Don't know; correct response = 1, incorrect or Don't know = 0.

A3. Applied Food-Safety Literacy (AFSL)

Appendix Table A3. AFSL Items

Code	Statement	Scale
AFSL1	I can interpret a sous-vide cooking instruction and identify the required time and temperature controls.	1 Strongly disagree – 5 Strongly agree
AFSL2	I can recognize when a cooking time–temperature combination may be unsafe or unsupported.	1–5
AFSL3	I can identify whether packaging is appropriate for the intended heating/contact conditions.	1–5
AFSL4	I can decide when cooked sous-vide food needs rapid chilling and refrigerated storage.	1–5
AFSL5	I can use food-safety information to decide whether a sous-vide practice is safe, unsafe, or non-recommended.	1–5

A4. Safety Self-Efficacy (SSE)

Appendix Table A4. SSE Items

Code	Statement	Scale
SSE1	I am confident that I can set and maintain the required sous-vide cooking temperature.	1 Strongly disagree – 5 Strongly agree
SSE2	I am confident that I can follow validated cooking instructions accurately.	1–5
SSE3	I am confident that I can cool and refrigerate cooked sous-vide food correctly when required.	1–5
SSE4	I am confident that I can reject a sous-vide practice when I am uncertain about its food-safety basis.	1–5

A5. Safe Sous-Vide Practice (SSP)

Appendix Table A5. SSP Items

Code	Statement	Scale
SSP1	I follow the specified cooking temperature rather than guessing it.	1 Never – 5 Always
SSP2	I follow the specified cooking time rather than relying only on appearance.	1–5
SSP3	I monitor the cooking process as required by the equipment or validated instructions.	1–5
SSP4	I use packaging intended for the relevant food-contact and heating conditions.	1–5
SSP5	I inspect pouches for damage or poor sealing before storage or service.	1–5
SSP6	I rapidly chill sous-vide food when it is intended for later refrigerated storage.	1–5

SSP7	I maintain appropriate refrigeration during storage of cooked sous-vide food.	1–5
SSP8	I follow the recommended or validated storage period before consuming the product.	1–5

A6. Potentially Unsafe and Non-Recommended Sous-Vide Practices (PUNSP)

Appendix Table A6. PUNSP Items

Code	Statement	Scale
PUNSP1	I guess the cooking temperature when a validated instruction is not available.	1 Never – 5 Very frequently
PUNSP2	I decide that food is safe because it looks or feels cooked, even when time–temperature requirements are uncertain.	1–5
PUNSP3	I use a lower cooking temperature because I assume lower temperature is automatically safer.	1–5
PUNSP4	I use a time–temperature combination that has not been validated or specified for the food.	1–5
PUNSP5	I use a food-contact bag without checking whether it is suitable for the intended heating conditions.	1–5
PUNSP6	I leave cooked sous-vide food at room temperature for an extended period before chilling or refrigeration.	1–5
PUNSP7	I assume vacuum packaging means the food does not require refrigeration.	1–5
PUNSP8	I keep refrigerated sous-vide food longer than the specified or validated storage period.	1–5
PUNSP9	I accept prolonged temperature abuse during transport or storage of cooked sous-vide food.	1–5
PUNSP10	I reheat or serve sous-vide food without checking the applicable product or validated instructions.	1–5

A7. Scoring and Derived Variables

Appendix Table A7. Scoring and Derived Variables

Variable	Derivation
SVK_Score_0to10	Sum of correct SVK responses; range 0–10.
AFSL_Mean	Mean of AFSL1–AFSL5; range 1–5.
SSE_Mean	Mean of SSE1–SSE4; range 1–5.
SSP_Mean	Mean of SSP1–SSP8; range 1–5.
PUNSP_Mean	Mean of PUNSP1–PUNSP10; range 1–5; higher values indicate more frequent unsafe/non-recommended practices.

REFERENCES

[1] Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Prentice-Hall.

[2] Bandura, A. (1997). *Self-efficacy: The exercise of control*. W. H. Freeman.

[3] Gupta, R. K., Pipliya, S., Karunanithi, S., Eswaran U, G. M., Kumar, S., Mandliya, S., Srivastav, P. P., Suthar, T., Shaikh, A. M., Harsányi, E., & Kovács, B. (2024). Migration of chemical compounds from packaging materials into packaged foods: Interaction, mechanism, assessment, and regulations. *Foods, 13*(19), 3125. https://doi.org/10.3390/foods13193125

[4] Misu, G. A., Canja, C. M., Lupu, M., & Matei, F. (2024). Advances and drawbacks of sous-vide technique—A critical review. *Foods, 13*(14), 2217. https://doi.org/10.3390/foods13142217

[5] Nissen, H., Rosnes, J. T., Brendehaug, J., & Kleiberg, G. H. (2002). Safety evaluation of sous vide-processed ready meals. *Letters in Applied Microbiology, 35*(5), 433–438. https://doi.org/10.1046/j.1472-765X.2002.01218.x

[6] Nutbeam, D. (2000). Health literacy as a public health goal: A challenge for contemporary health education and communication strategies into the 21st century. *Health Promotion International, 15*(3), 259–267. https://doi.org/10.1093/heapro/15.3.259

[7] Onyeaka, H., Nwabor, O., Jang, S., Obileke, K., Hart, A., Anumudu, C., & Miri, T. (2022). Sous vide processing: A viable approach for the assurance of microbial food safety. *Journal of the Science of Food and Agriculture, 102*(9), 3503–3512. https://doi.org/10.1002/jsfa.11836

[8] Panou, A., & Karabagias, I. K. (2024). Migration and safety aspects of plastic food packaging materials: Need for reconsideration? *Coatings, 14*(2), 168. https://doi.org/10.3390/coatings14020168

[9] Romeo, M., Lavilla, M., & Amárita, F. (2024). Microbial food safety of sous vide cooking processes of chicken and eggs. *Foods, 13*(19), 3187. https://doi.org/10.3390/foods13193187

[10] Seref, N., & Cufaoglu, G. (2025). Food packaging and chemical migration: A food safety perspective. *Journal of Food Science, 90*(5), e70265. https://doi.org/10.1111/1750-3841.70265

[11] U.S. Food and Drug Administration. (2022). *Food Code 2022*. https://www.fda.gov/food/fda-food-code/food-code-2022

[12] Zhang, Q., Huo, Y., Yang, Q., Zhao, F., Li, M., & Ju, J. (2025). Migration of chemical substances from packaging materials to food. *Food Chemistry, 485*, 144544. https://doi.org/10.1016/j.foodchem.2025.144544