Research Artikel

IMPROVING NUTRITION LITERACY SKILLS OF PROSPECTIVE CHEMISTRY TEACHERS: IMPLEMENTING GUIDED INQUIRY IN FOOD ADDITIVES LEARNING

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Abstract

The importance of integrating nutrional literacy into the competenceies of prospective chemistry teachers, which is directed at having knowledge about food, such as understanding various types of food that contain additives and forming healthy lifestyle habits. This study aims to investigate the implementation of guided inquiry in teaching about food additives and to examine its impact on prospective chemistry teachers' nutrition literacy, thereby contributing to the design of effective educational interventions that connect academic knowledge with everyday health practices. A mixed-methods sequential explanatory approach was employed with the instruments of questionnaires, interviews, and N-Gain analysis of pretest-posttest to assess improvements in the nutrition literacy of prospective chemistry teachers. The sample of this research involved 30 sixth-semester students from the Chemistry Education Program at a university in Bandung. The results showed that prospective chemistry teachers demonstrated adequate knowledge of food composition and additives, the ability to manage a balanced diet, and positive attitudes toward healthy food consumption. The N-Gain analysis revealed a significant improvement, with an overall average of 0.72 (high category). Specifically, the high-achievement group achieved 0.78 (high), the low-achievement group 0.61 (high), and the moderate-achievement group 0.78 (moderate). Interview findings reinforced these results, revealing that prospective chemistry teachers were able to identify food types and nutritional values, distinguish between natural and synthetic additives, recognize the importance of safe consumption limits, and highlight challenges related to reporting hazardous additives and accessing foods with fewer additives. In conclusion, guided inquiry learning enhances academic ability with fostering active learning, deeper understanding, and higher-order thinking, so the results show increase prospective chemistry teachers' nutrition literacy and equipping them with practical decision-making skills, making it a valuable educational intervention for fostering healthier lifestyles.

Keywords: *Nutrition literacy, guided inquiry, food additives, prospective chemistry teachers*

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INTRODUCTION

Nutrition literacy is defined as an individual's level of knowledge and skills—fundamental, interactive, and critical—related to food and nutrition, which in turn influence the selection of appropriate foods for consumption (Samruayruen & Kitreerawutiwong, 2022). Therefore, nutrition literacy also leads to the development of healthy lifestyle habits. (Yavaş et al., 2024). Nutrition literacy covers various aspects of food knowledge; one area that is still underexplored is the understanding of food additives.

Additives are defined as substances added to food to preserve and improve taste, texture, or appearance (Savin et al., 2022). An often-overlooked component is understanding additives (e.g., preservatives, artificial flavours, colours, sweeteners, and emulsifiers) in processed foods. Research from Warner (2024) shows that high intake of additives is associated with risks of cardiovascular disease and depression in adults, childhood obesity, metabolic syndrome, and cancer. Data also shows that additives have a higher toxic potential in children, so it is necessary to adhere to the precautionary principle, namely by preventing the risk of harm that may arise (Kraemer et al., 2022).

This indicates the need for schools to play a role in increasing awareness of healthy lifestyles in learning, especially in the aspect of nutrition literacy knowledge, which can encourage healthier behavioural practices (Samad et al., 2024). As future science educators, prospective chemistry teachers require a comprehensive understanding of nutrition literacy—especially regarding food additives—to effectively educate students and serve as role models. To achieve this, innovative pedagogical approaches are essential.

Research from Nurdin (2025) show that project-based learning can effectively improve students' nutrition literacy. Otherwise, nutrition literacy can improve behaviours of habits healthy life of outpatient nutrition clinics (Marchello et al., 2021).

Guided inquiry-based learning has emerged as a promising strategy to enhance students' critical thinking and engagement in science education (Anwar et al., 2024). By allowing students to investigate real-world problems—such as analysing food labels or testing for preservatives—guided inquiry fosters deeper understanding and empowers adolescents to make informed dietary choices (Hammond et al., 2023).

The novelty of this study lies in integrating the concept of nutrition literacy—specifically focused on food additives—into the training of prospective chemistry teachers through guided inquiry-based learning. While previous studies have primarily examined nutrition literacy among adolescents or general populations, limited research has explored its development within teacher education contexts, especially through inquiry-driven approaches that link chemistry content with everyday dietary behaviour. This study, therefore, provides new insights into how guided inquiry can be used to strengthen prospective chemistry teachers' scientific literacy and promote healthier educational practices.

Therefore, this study aims to investigate the implementation of guided inquiry in teaching about food additives and examine its impact on prospective chemistry teachers' nutrition literacy, thereby contributing to the design of effective educational interventions that bridge academic knowledge with everyday health practices.Click or tap here to enter text.

METHOD

This study involved 30 sixth-semester students from the Chemistry Education Study Program at a university in Bandung who were enrolled in the Food Additives and Preservatives course. The participants were

selected using purposive sampling with the following criteria: (1) active enrolment in the current semester, (2) prior completion of courses on food additives, and (3) willingness to fully participate in the research process. This sampling technique was chosen because it aligned with the objectives and goals of the study, thereby enhancing research accuracy and strengthening the reliability of the data and findings (Campbell et al., 2020).

This study employed mixed method sequential explanatory (Sugiyono, 2015). This method with the independent variable being the implementation of guided learning worksheets on food additives, and the dependent variable being the improvement of students' nutrition literacy. A pre-experimental design with one group pre-test and post-test was applied, indicating that no control group was used Table 1.

Table 1. One Group Pretest-Post-test Pre-Experimental Design

Pretest	Treatment	Post-test
O_1	X	O_2

Quantitative data were obtained from students' pre-test and post-test scores on food additives to measure their nutritional literacy. Qualitative data were collected through attitude questionnaires and interview responses to provide a more comprehensive description of students' nutritional literacy. A one-group pre-test–post-test design was employed to examine the improvement in students' nutritional literacy before and after the implementation of guided inquiry worksheets on food additives.

The research procedure consisted of three stages: preparation, implementation, and final stage. The overall procedure is illustrated in Figure 1.
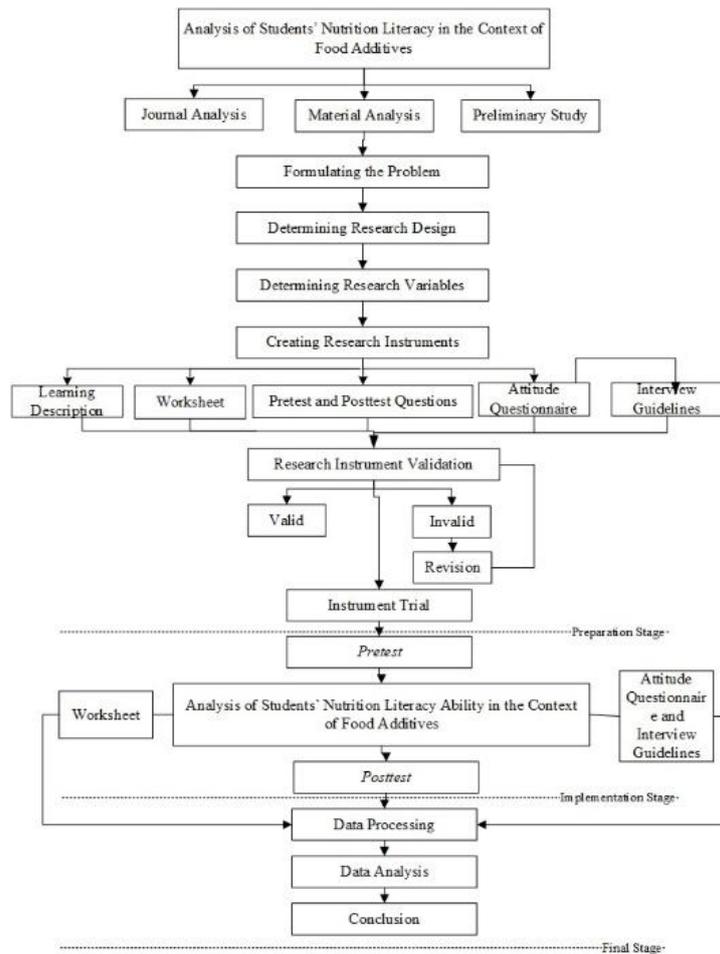

Figure 1. Research Procedure

The research instruments consisted of a learning description, worksheets, pretest and post-test questions, attitude questionnaires, and interview guidelines. Data on nutrition literacy skills were collected from the pretest and post-test results based on the question indicators presented in Table 2.

Table 2. Question Indicators

Indicators of Nutrition Literacy	Indicators of Questions
Knowledge of Food Types	Ability to classify different types of food additives (e.g., preservatives, colorants, flavour enhancers, sweeteners)
Knowledge of the Importance of Nutrition	Ability to explain the purpose and function of various food additives in processed food
	Ability to analyse the contribution of additives to food quality, safety, and shelf life
	Ability to evaluate the benefits and potential risks of food additives to human health
Knowledge of Nutrient Sources	Ability to read and analyse food labels to identify additives contained in the product
	Ability to determine the appropriateness of additive usage compared with national or international standards
Competence in Managing a Balanced Diet	Ability to calculate or estimate the safe intake level of certain additives
	Ability to evaluate whether the consumption of processed foods with additives still complies with balanced diet principles
Healthy Living Behaviour in Daily Life	Ability to evaluate personal or community dietary habits that involve high consumption of additive-containing foods
	Ability to design healthier alternatives (e.g., low-additive snacks or drinks)
Receptive Attitude Toward	Ability to respond positively to educational campaigns about the risks and safe use of food additives
Encouragement to Consume Healthy and Nutritious Food	Ability to design or support initiatives to encourage reduced consumption of excessive food additives

Data analysis was conducted by first performing a normality test on the pretest and post-test results as a prerequisite for applying parametric tests. Hypothesis testing was then carried out using a paired sample t-test to examine the improvement in students' nutrition literacy. Following this, an N-gain test was employed to determine the distribution of literacy improvement across high, medium, and low achievement groups. Finally, the obtained N-gain values were interpreted with reference to Table 3.

Table 3. Interpretation of N-Gain Value

N-Gain Index	Interpretation
$g > 0.70$	High
$0.30 \leq g \leq 0.70$	Moderate
$g < 0.30$	Low

RESULTS AND DISCUSSION

Implementation of improving nutrition literacy skills in guided inquiry learning on additive materials

Nutrition literacy posits that a foundational, interactive, and critical understanding of nutrition is essential for developing effective interventions to foster healthy lifestyle patterns and habits (Silva, 2023). Nutrition literacy is crucial for comprehending the consumption of food products containing additives, which have gained widespread acceptance. Nevertheless, an inadequate understanding of their safety aspects may lead to adverse health outcomes (Osaili et al., 2023). A key effort to address this challenge involves implementing a learning model designed to facilitate the measurement of nutrition literacy. This approach provides a structured framework for assessing students' comprehension and application of key dietary concepts.

Educational interventions concerning foods with additives in school settings are effectively enhanced with food models as a medium, complemented by suitable pedagogical models (St. Pierre et al., 2024). The assessment of nutrition literacy skills within the framework of guided inquiry learning requires the implementation of a systematically structured instructional plan. A lesson plan constitutes a systematically organized sequence of learning activities, deliberately structured to achieve precise and well-defined instructional objectives (Orr et al., 2022).

This study used a guided inquiry learning model that included stages from orientation to drawing conclusions as described in Table 4.

Table 4. Learning Activities with Guided Inquiry Learning

Nutrition Literacy Indicators	Guided Inquiry Stage	Learning Activities
Knowledge of food types	Orientation	Students were presented with a selection of diverse food products (e.g. fresh fruit, packaged snacks, bottled drinks) and then given a stimulus with the question "How do these products differ in terms of nutritional content and the presence of additives?"
Knowledge of the importance of nutrition	Formulating Questions	The students were organized into six groups, with each group assigned different food products within the same categories (fresh fruit, packaged snacks, and bottled drinks). Subsequently, the students were provided with the nutritional information of each product type and instructed to formulate a set of inquiry questions on the additive content and nutritional value of the respective products.
Knowledge of nutrient sources		Students were instructed to formulate problem statements concerning the significance of nutrients for the human body and to identify appropriate food sources that can fulfill nutritional requirements.
Knowledge of the importance of nutrition Knowledge of nutrient sources	Hypothesis/Prediction	The students formulated hypotheses as tentative explanations to address the problem statements developed in relation to the importance of nutrition and the identification of nutrient sources.
Competence in managing a balanced diet	Data Collection	The students were instructed to determine the daily nutritional requirements for each group member based on their weight and age. Subsequently, they sought information about types of additives and the recommended safe limits for the consumption of additives contained in the selected products.
Healthy living behavior in daily life		The students were guided to design a one-day dietary plan that ensures nutritional balance while minimizing additive intake.
Receptive attitude toward encouragement to consume healthy and nutritious food	Data Analysis	The students will compare the daily nutritional requirements of each group member and analyze the underlying factors contributing to these differences. Additionally, they will examine the nutritional composition of food products containing additives and provide reasonable explanations for the necessity of limiting their consumption. Students present the results of their group discussions in front of the class.
	Conclusion	The students draw conclusions regarding patterns of additive consumption in food products by considering the nutritional requirements of the human body.

Anallysis of the Improvement of Students' Nutrition Literacy on Food Additives

The analysis of the improvement in nutrition literacy began with a normality test on the pretest and post-test scores. The results showed a significance value of 0.380 for the pretest and 0.119 for the post-test. For normality testing with samples fewer than 50, the Shapiro–Wilk test was used, in which the data are considered normally distributed if the significance value is greater than 0.05 (Notoadmojo, 2018). Thus, both the pretest and post-test data were normally distributed.

The next stage was hypothesis testing using a paired sample t-test. At this stage, the null hypothesis (H_0) stated that there was no significant improvement in nutrition literacy after the implementation of guided inquiry learning on food additives. In contrast, the alternative hypothesis (H_a) stated that there was a significant improvement in nutrition literacy after the implementation of guided inquiry learning on food additives. The paired sample t-test was conducted using SPSS software, with the criterion that if the significance value were less than 0.05, H_0 would be rejected and H_a would be accepted (Nuryadi et al., 2017). In this study, the results of the paired sample t-test showed a significance value of 0.001, indicating a significant improvement in nutrition literacy after the implementation of guided inquiry learning on food additives. This result is presented in Table 5.

Table 5. Result of paired sample t-test

Analysis Tool	SPSS software
Result of Paired Sample t-test	Significance value = 0.001
Conclusion	Significance improvement in nutrition literacy

The final stage was the N-Gain test, which was conducted to determine the extent of improvement in nutrition literacy for each achievement group. The result of the N-Gain test is presented in Table 6.

Table 6. Result of N-Gain Analysis

Achievement Group	Average Pretest Score	Average Posttest Score	N-Gain	Interpretation
High	65.59	92.64	0.78	High
Moderate	55.39	90.33	0.78	High
Low	53.25	81.87	0.61	Moderate
Average	58.07	88.28	0.72	High

Based on the results shown in Table 6, the average N-gain value was 0.72, which is categorized as high, indicating that the implemented learning strategy was effective in enhancing students' nutrition literacy. This finding is consistent with Coletta & Steinert (2020), who emphasized that a high N-gain score reflects the success of an instructional strategy in significantly improving conceptual understanding and, therefore, can serve as an indicator of teaching effectiveness.

The high category was achieved by both the high-achievement group and the moderate-achievement group, each obtaining an N-gain of 0.78. This result indicates that students in these groups were able to make optimal use of the learning strategy, achieving post-test scores close to the maximum possible score. The relatively lower pretest scores compared to the post-test scores suggest substantial room for improvement; thus, when an effective learning strategy was implemented, the achievement gains became significant. This finding is consistent of Nissen et al. (2018), who stated that a high N-gain reflects the success of a learning strategy in significantly facilitating the attainment of target competencies.

The low-achievement group obtained an N-gain of 0.61, which falls into the moderate category, indicating noticeable improvement, although not as high as that of the other two groups. Several factors may have contributed to this result, including differences in learning motivation, variations in self-study strategies, and limitations in applying the acquired skills during the learning process. According to Zhao et al. (2025), an N-gain in the medium category still reflects the effectiveness of the intervention but suggests the need for strategy modifications

to optimize outcomes, such as providing more intensive scaffolding or enriching contextual examples.

Overall, the average N-gain of 0.72 across all groups falls within the high category, showing that the applied learning approach was generally effective for students with varying achievement levels. However, the moderate N-gain of the low-achievement group indicates that instructional adjustments—such as more structured guidance or differentiated learning support—may help ensure equitable learning outcomes. This aligns with Liou et al. (2023) and Smale-Jacobse et al. (2019) who emphasize that tailoring instruction to students' learning characteristics can enhance both engagement and achievement.

Analysis of Attitude Questionnaires and Interview Result on Nutrition Literacy of Food Additives

Nutrition literacy is an integration of knowledge, skills, and attitudes that guide individuals in making decisions regarding the consumption of foods that are beneficial to healthh (Silva et al., 2023). The attitude component can be measured using an attitude questionnaire to examine the extent to which nutrition literacy is implemented (Zhang et al., 2022). In this study, the results of the attitude questionnaire on nutrition literacy related to food additives are presented in Table 7.

Table 7. Result of The Attitude Questionnaire

Indicators of Nutrition Literacy	Statement	Types of Statements	Students' Responses
Knowledge of Food Types	I need to gather information regarding the types of food additives present in food products that are consumed	Positive (+)	**1 (SA): 76.7%** 2 (A): 23.3% 3 (N): 0% 4 (D): 0% 5 (SD): 0%
Knowledge of the Importance of Nutrition	I need to examine the composition and nutritional information provided on the packaging label	Positive (+)	**1 (SA): 70%** 2 (A): 30% 3 (N): 0% 4 (D): 0% 5 (SD): 0%
Knowledge of Nutrient Sources	I need to use natural additives more frequently than synthetic additives	Positive (+)	**1 (SA): 50%** 2 (A): 46.7% 3 (N): 3.3% 4 (D): 0% 5 (SD): 0%
Competence in Managing a Balanced Diet	I need to understand the safety limits of food additive consumption	Positive (+)	**1 (SA): 83.3%** 2 (A): 16.7% 3 (N): 0% 4 (D): 0% 5 (SD): 0%
	I need to reduce the use of food additives in the foods and beverages I consume	Positive (+)	**1 (SA): 70%** 2 (A): 26.7% 3 (N): 3.3% 4 (D): 0% 5 (SD): 0%
Healthy Living Behavior in Daily Life	If someone is found using harmful additives, I will report it	Positive (+)	1 (SA): 30% **2 (A): 43.3%** 3 (N): 26.7% 4 (D): 0% 5 (SD): 0%
	I need to consume food and drinks with minimal use of additives	Positive (+)	**1 (SA): 50%** 2 (A): 40% 3 (N): 3.3% 4 (D): 6.7% 5 (SD): 0%
Receptive Attitude Toward Encouragement to	I do not need to inform others if I consume food products with harmful additives	Negative (-)	1 (SA): 0% 2 (A): 0% 3 (N): 6.7%

Indicators of Nutrition Literacy	Statement	Types of Statements	Students' Responses
Consume Healthy and Nutritious Food			4 (D): 33.3% **5 (SD): 60%**
	I do not need to seek information about the health risks of food additives when consumed in excess	Negative (-)	1 (SA): 0% 2 (A): 0% 3 (N): 0% 4 (D): 23.3% **5 (SD): 76.7%**
	If there are issues regarding the dangers of food additives, I do not need to pay attention to them	Negative (-)	1 (SA): 0% 2 (A): 0% 3 (N): 0% 4 (D): 30% **5 (SD): 70%**

The data in Table 7 illustrate that, in the indicator of knowledge regarding the importance of food types and nutrition, more than 70% of students strongly agreed and approximately 30% agreed that it is necessary to know information such as the composition and nutritional value of various food products containing additives. The interview results reinforced these findings by showing that students considered it important to know the types of food, the composition of ingredients used—including additives—and their nutritional values, as consumers need to be aware of what substances enter their bodies since these will ultimately affect health. This result is consistent with the study by Osaili et al. (2023), in which respondents' data indicated a strong demand for information on food additives presented on labels, such as the number of additives added, ingredient composition, and nutritional value.

The nutrition literacy indicator concerning knowledge of food types and the importance of nutrition is reflected in the ability to identify the kinds of food required to meet energy needs and maintain health, as well as in the understanding of the role of nutrients (Nasrudin et al., 2023). The interview results also showed that students were already able to distinguish the types of food they needed, such as foods containing carbohydrates, proteins, and fats, and recognized the health risks that could arise if they did not consider the types of food consumed, including the excessive intake of food additives. For prospective chemistry teacher, such understanding is not only essential for personal health awareness but also contributes to their pedagogical competence. By linking nutritional content to underlying chemical principles (e.g., organic compounds, biomolecules, or the synthesis of food additives), they can design contextual learning experiences that help students relate chemistry to everyday life (Rodrigues et al., 2022).

For the indicator of knowledge about sources of nutrition, the data in Table 6 show that 50% of students strongly agreed, 46.7% agreed, and 3.3% were uncertain regarding the statement that natural food additives should be used more frequently than synthetic additives. This finding was supported by interview results, which indicated that students who agreed expressed the view that natural additives are preferable to synthetic ones because they are derived from naturally occurring substances, whereas synthetic additives are obtained through chemical processes. In addition, students stated that the use of these additives could affect the nutritional content of food or beverages. This highlights the need to consider balanced nutritional requirements for the body as an investment in health. Similar findings from Kim et al. (2025) describe that the use of natural additives and the movement toward synthetic additive–free products have been increasingly promoted to preserve the nutritional quality of food products. The data in Table 6 also show that 3.3% of students responded with uncertainty. The interview results indicated that these students believed

synthetic additives are not always harmful to health, if they are still consumed within acceptable limits. For prospective chemistry teachers, this skill aligns with the professional competence of modelling health-conscious behaviour based on scientific reasoning. By understanding the chemistry of food additives and their effects on the body, they can guide students toward evidence-based attitudes in choosing and consuming food responsibly.

The success indicator of knowledge about sources of nutrition lies in the understanding of the role of nutrients in meeting the body's needs and the ability to make healthier and more balanced food choices (Nasrudin et al., 2023). The analysis of the interview data showed that students had demonstrated an understanding of this nutrition literacy indicator. This was evidenced by their statements indicating that they were able to decide which types of food to consume based on balanced nutritional needs. In addition, students were also able to consider the use and consumption of both natural and synthetic additives. This finding is consistent with Guiné et al. (2023), who stated that nutritional knowledge can influence healthy living attitudes, particularly in food choices.

For the indicator of skills in managing a balanced diet, the majority of students agreed (83.3% strongly agree) that it is important to know the safe limits and to restrict the consumption of foods containing additives. This finding was supported by interview results, which highlighted the importance of being aware of the safe intake levels of food additives and limiting their use. Excessive consumption beyond these limits may lead to health problems. Students also expressed that limiting additive intake is a step toward maintaining a balanced diet, meaning that when consuming foods containing additives, it should be counterbalanced with real foods free from additives. This is reinforced by the statement that the ability to maintain a balanced diet serves as an appropriate preventive measure

against health problems related to individual dietary habits (Lai et al., 2021).

The success indicator of skills in managing a balanced diet is reflected in an individual's ability to select, process, and healthily consume food according to the body's needs (Nasrudin et al., 2023). This finding is consistent with the results of the attitude questionnaire and interview data, which showed that students were able to choose and process the types of food they needed to consume, including considering the amount of food additives based on their safe limits of use.

For the indicator of healthy lifestyle behavior in daily life, varied responses were found regarding the statement about reporting individuals who use hazardous food additives, including 26.7% of students who were uncertain. This highlights the need for follow-up efforts to reinforce the importance of paying attention to the safety of foods and beverages consumed (Ali et al., 2023). The interview findings revealed that students who were uncertain expressed the view that reporting was complicated and not their personal responsibility. On the other hand, students who agreed with the statement emphasized that hazardous additives must be avoided and should be reported to the authorities, as this concerns public safety. Furthermore, regarding the statement on the necessity of consuming foods and beverages with minimal additives, 6.7% of students disagreed. This finding indicates the importance of investigating the reasons behind such disagreement, as fostering healthy lifestyle behaviours requires minimizing excessive additive consumption, which can be harmful to health. This situation may arise due to frequent misinformation regarding the role of food additives in various products (Lu et al., 2024). The interview data showed that these students found it difficult to access foods that are truly low in additives in their environment. However, this challenge can be addressed by preparing food independently, allowing individuals to better control the

number of additives used. Students who agreed on the importance of minimizing additives also expressed that such substances should not be consumed in excessive amounts, thus highlighting the need for careful food selection. In addition to monitoring dietary intake, maintaining balance through physical activity, such as exercise, was also emphasized. This aligns with the success indicator of healthy lifestyle behaviour in nutrition literacy, which involves maintaining a balance between nutritional intake and physical activity (Nasrudin et al., 2023).

For the indicator of having a positive attitude or being receptive toward suggestions to consume healthy and nutritious foods, it was found that 6.7% of students uncertain with the statement that it is unnecessary to inform others when consuming food products containing hazardous additives. The interview findings revealed that these students expressed difficulties in advising others to avoid hazardous additives, as people in their surroundings tended not to recognize the level of danger associated with additives, considering their use as common practice. Moreover, the interview data also showed that when asked about the appropriate response to the widespread circulation of food products containing prohibited additives, students emphasized the need for education or public awareness campaigns concerning the risks of such food products. This is necessary because fostering healthy lifestyle attitudes must begin with sufficient knowledge, making education a viable solution for society. These findings also highlight the attitudinal competence required of future chemistry teachers, who should be open to promoting critical awareness about chemical substances in food and their health impacts. This aligns with the broader goal of developing scientifically literate citizens through chemistry education that connects science, health, and society (Wiyarsi et al., 2021).

CONCLUSION

The findings show that the implementation of guided inquiry in teaching about food additives effectively enhanced prospective chemistry teacher nutrition literacy, as demonstrated by improvements in knowledge, skills in managing a balanced diet, and positive attitudes toward healthy food choices. Together, these results indicate that guided inquiry not only improves academic understanding but also equips students with practical decision-making skills for healthier lifestyles, emphasizing its value as an effective educational intervention. Collectively, these results indicate that guided inquiry not only improves academic understanding but also develops scientific literacy and decision-making competence among prospective chemistry teachers, enabling them to apply chemistry concepts to real-life contexts related to food, health, and sustainability. Thus, guided inquiry serves as an effective pedagogical approach for preparing future chemistry educators who can integrate chemical knowledge with health-conscious and socially responsible practice.

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