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Empowering women through Gynura procumbens cookies for diabetes prevention and functional food production

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ABSTRACT

Diabetes prevention at the community level requires both proper health knowledge and practical skills that simultaneously support healthier food choices and local empowerment. This community service program aimed to strengthen women's knowledge of diabetes prevention and their capacity to produce Gynura procumbens based functional cookies. A participatory community empowerment approach was implemented including health education, demonstrations, hands-on production practice, mentoring, and introductory entrepreneurship and digital marketing activities involving PKK members and community participants in Sapanang Village, Jeneponto. Twelve participants completed the pre-test, while seven completed matched pre-test & post-test evaluations. Knowledge was assessed using a structured questionnaire, and production skills were evaluated through direct observation during practice. Among the seven participants with complete paired data, the mean knowledge score increased from 74.29 to 95.71 percent, representing a 21.42-percentage-point improvement. All seven participants achieved the good-knowledge category at post-test. All 12 participants successfully completed the supervised functional-cookie production practice. The program demonstrates that combining diabetes-prevention education with practical functional-food production can strengthen women's health literacy and productive capacity, providing a feasible model for community-based health promotion using locally relevant herbal resources.

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1. INTRODUCTION

Diabetes mellitus remains a major global public health challenge, with a growing detection in low- and middle-income countries. In Indonesia, approximately 20.4 million adults aged 20–79 years were estimated to be living with diabetes in 2024, placing the country among those with the highest number

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of adults affected worldwide (International Diabetes Federation, 2025). National data also indicate a gap between diagnosed diabetes and diabetes identified through blood glucose examination, suggesting that prevention, early awareness, and community-level health literacy remain important public health priorities (Kementerian Kesehatan Republik Indonesia, 2023). Current recommendations emphasize healthy dietary patterns, regular physical activity, weight management, and sustained health education as fundamental strategies for preventing or delaying type 2 diabetes and its complications (American Diabetes Association, 2026). These recommendations highlight the importance of preventive programs that translate health information into practical behaviors that can be adopted in everyday community settings.

Community-based strategies are particularly relevant. Apart from individual knowledge, diabetes prevention is also primarily driven by family practices, social environments, access to healthier food options, and opportunities for sustained community participation (Harris et al., 2019). Evidence from low- and middle-income countries shows that meaningful community engagement can strengthen agency, empowerment, shared understanding, and participation in non-communicable disease prevention (Klingberg et al., 2024). Fottrell et al. (2025) further demonstrated that a Participatory Learning and Action approach implemented through community groups in rural Bangladesh substantially improved diabetes-related knowledge, although effects on metabolic outcomes varies. These findings suggest that community empowerment can produce meaningful early changes in health literacy and practical capacity, while longer-term clinical outcomes require sustained intervention and follow-up.

The community partner in this program was the Family Welfare Empowerment group (*Pemberdayaan dan Kesejahteraan Keluarga, PKK*) and community members of Sapanang Village, Binamu District, Jeneponto Regency, South Sulawesi. A preliminary partner assessment identified approximately 370 residents who had been diagnosed with diabetes, while access to structured diabetes-prevention education and healthier food alternatives remained limited. Sapanang Village has an active PKK group that represents important social capital for family welfare, community health promotion, and women's productive activities. However, opportunities to develop healthy food innovations using local herbal resources were still limited. Community members also required advancing capacities in standardized food processing, food hygiene and safety, packaging, microenterprise management, and digital marketing. These conditions indicate that the partner's needs extend beyond health education to practical competencies that potentially enable women to implement health knowledge into productive community-based activities.

One locally relevant opportunity is the development of a *Gynura procumbens* based functional-cookie prototype, conceived as a product-development concept using a locally relevant plant ingredient. *Gynura procumbens* (locally known as sambung nyawa) is a medicinal plant widely recognized in Southeast Asia (Setyawati et al., 2023). *Gynura procumbens* contains several bioactive constituents, particularly flavonoids such as astragalin, kaempferol, quercetin, myricetin, and rutin. Experimental evidence has reported antioxidant and antiglycemic activities associated with this plant, supporting its potential for further development as a health-oriented food ingredient (Bose et al., 2025). Other experimental studies have also reported biological effects of *Gynura procumbens* in diabetic models, including effects related to pancreatic histopathology and diabetic wound-healing pathways (Dewatisari et al., 2025; Situmorang et al., 2025). However, the available evidence remains predominantly experimental, and clinical evidence regarding processed *Gynura procumbens* based food products remains limited.

Accordingly, in this program, the term "functional food" was used as a product-development concept referring to a food product formulated with a locally relevant plant ingredient that has been reported to contain bioactive compounds in experimental studies. The term does not imply that the

resulting cookies have demonstrated physiological, metabolic, preventive, or therapeutic effects in humans. No nutritional composition analysis, bioactive-compound quantification, or clinical efficacy testing of the cookies was conducted in this program. Therefore, *Gynura procumbens* was positioned as a functional-food ingredient and educational medium rather than as a therapeutic product in which claimed to prevent or treat diabetes.

Integrating health education with functional-food production offers an opportunity to implement knowledge into practical skills. Rather than providing diabetes-prevention education as an independent activity, this program simultaneously conducted health education with hands-on production of *Gynura procumbens* based functional cookies. Appropriate household-scale technology, including ovens, digital weighing equipment, mixers, sealing equipment, and standardized production procedures, was introduced to facilitate consistent and hygienic food processing. Participants were also introduced to food hygiene and sanitation, product packaging, production-cost calculation, simple financial management, branding, and digital marketing. These components directly addressed the needs identified among the community partners and were intended to move participants from passive recipients of health information toward active application of knowledge through functional-food production.

The integration of participatory education, practical training, appropriate technology, and entrepreneurship support is also consistent with evidence that community-driven health promotion is more likely to be sustained when capacity building is equipped by technical assistance, partnerships, and continued community involvement (Clark et al., 2024). In Sapanang Village, strengthening the capacity of women through the PKK is particularly relevant because PKK members have established roles within families and community activities and may serve as local agents for disseminating health information. Concurrently, developing skills in functional-food production provides an opportunity to strengthen productive capacity using local herbal resources. The program, therefore, was designed to address two interconnected partner needs: strengthening diabetes-prevention literacy and enhancing women's capacity to develop a community-based functional-food product.

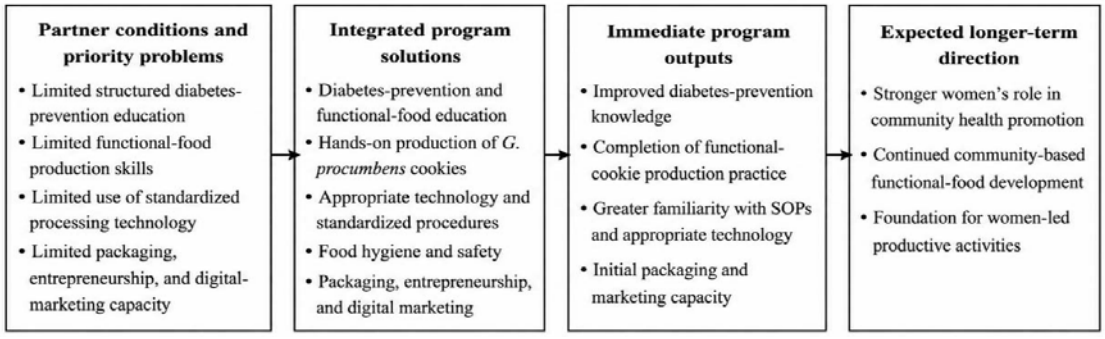


Figure 1. Problem-solving framework for women's empowerment through *Gynura procumbens* based functional-food production

Based on these identified needs, the program applied a participatory community empowerment approach that integrated diabetes-prevention education, functional-food literacy, hands-on production of *Gynura procumbens* based cookies, appropriate food-processing technology, food hygiene and safety, packaging, basic entrepreneurship, and digital marketing. The problem-solving framework linking the partner's identified problems, program interventions, immediate outputs, and expected longer-term direction is presented in Figure 1. The primary objective of this community service program was to improve women's knowledge of diabetes prevention and strengthen their practical capacity to produce *Gynura*

procumbens based functional cookies. In addition, the program aimed to introduce basic competencies in hygienic food processing, appropriate production technology, packaging, entrepreneurship, and digital marketing as an initial foundation for sustainable community-based functional-food development.

2. METHODS

Program Design and Settings

This community service program used a participatory community empowerment approach that integrated health education, experiential learning, hands-on functional-food production, mentoring, and program evaluation. The approach was selected to position community members as active partners who participated in the learning and production process rather than as passive recipients of health information. The program combined diabetes-prevention education with practical skills development in *Gynura procumbens* based functional-food production, appropriate food-processing technology, food hygiene and safety, packaging, basic entrepreneurship, and digital marketing.

The program was implemented in Sapanang Village, a village located in Binamu District, Jeneponto Regency, South Sulawesi, Indonesia, in which collaborated with the village government and the Family Welfare Empowerment group (Pemberdayaan dan Kesejahteraan Keluarga, PKK). Preparatory discussions with the village government and PKK representatives were held before the main activity to identify community needs, determine participant involvement, prepare the venue and supporting facilities, and organize the training materials and equipment. The main activity was conducted on July 10, 2026. Twelve PKK members and community participants participated in the initial assessment and main program activities.

Implementation Team and Partner Involvement

The implementation team consisted of members from diverse academic and professional backgrounds, including lecturers with expertise in medical-surgical nursing and community nursing, a lecturer from the Faculty of Economics, nursing students, including students participating in the university's Community Service Program (Kuliah Kerja Nyata, KKN), and a baking expert from Evely Cake and Bakery. The nursing lecturers were responsible for preparing and delivering education on diabetes prevention and functional-food literacy, facilitating the introduction of *Gynura procumbens* as a functional-food ingredient, and supporting hygienic food-processing practices. The lecturer from the Faculty of Economics provided introductory training on entrepreneurship, production-cost calculation, product pricing, branding, and digital marketing. The baking expert from Evely Cake and Bakery served as a technical resource person during the hands-on session, providing practical guidance on cookie formulation, dough preparation, shaping, baking techniques, product consistency, and basic presentation and packaging. Nursing students, including KKN students, served as field assistants and supported participant registration, small-group facilitation, practical demonstrations, documentation, and peer-coaching, particularly for participants who required additional assistance during the hands-on sessions.

The Government of Sapanang Village and PKK representatives contributed to community coordination, participant mobilization, preparation of the activity venue, and provision of local facilities. Throughout the program, participants were actively involved in interactive discussions, ingredient preparation, operation of production equipment, cookie processing, hygienic handling, packaging, and introductory product-marketing activities. The multidisciplinary collaboration among nursing, economics, a professional baking practitioner, students, village authorities, and community partners was

designed to integrate health education with practical food-production and entrepreneurship skills. This participatory approach enabled participants to learn through direct experience while strengthening the partner's initial capacity to continue functional-food production and related community-based activities beyond the facilitated program.

Program Implementation

The program was implemented through three interconnected stages: pre-activity preparation and baseline assessment, integrated education and practical training, and monitoring and evaluation. The implementation framework is summarized in Table 1.

Table 1. Program implementation and evaluation framework

Stage	Main Activities	Tools/Materials	Evaluation
Pre-activity preparation	Preparatory discussions with village government and PKK representatives; identification of partner needs; participant recruitment; preparation of educational and production materials	Educational materials, training facilities, knowledge questionnaire	Partner needs and baseline participant characteristics
Baseline assessment	Administration of pre-test before educational activities	10-item knowledge questionnaire	Baseline diabetes-prevention and functional-food knowledge
Health and functional-food education	Interactive education and discussion on diabetes, risk factors, prevention, healthy dietary practices, dietary fiber, functional foods, and local herbal resources	Educational materials and facilitated discussion	Participant engagement and response during discussion
Functional-cookie production	Demonstration followed by hands-on preparation of *Gynura procumbens* based functional cookies	*Gynura procumbens* and cookie ingredients, digital scale, mixer, oven, production SOP	Direct observation of production stages and hygienic procedures
Entrepreneurship and digital marketing	Introduction to production-cost calculation, product pricing, packaging, branding, WhatsApp Business, and Instagram	Packaging materials and digital-media platforms	Participation and completion of introductory activities
Final evaluation	Post-test, practical observation, product feedback, and discussion of follow-up activities	Questionnaire, production SOP, product-acceptability evaluation	Knowledge change, practical achievement, and initial consumer feedback

During the pre-activity stage, the facilitator team aligned with the village government and PKK representatives to identify the partner's priority needs and prepare the implementation process. Before receiving any educational material, participants completed a 10-item knowledge pre-test covering the definition and symptoms of diabetes, diabetes risk factors and prevention, healthy dietary practices, functional foods, utilization of local resources, functional-cookie development, and hygienic food processing.

The educational component was interactively delivered through explanation, discussion, and question-and-answer activities. The content focused on diabetes risk factors, preventive behaviors, healthy dietary practices, the importance of dietary fiber, the concept of functional food, and the potential utilization of *Gynura procumbens* as a locally available herbal ingredient. Participants were encouraged to relate the information to their existing dietary and food-processing practices and to discuss questions arising from their everyday experiences.

The educational activity was followed by demonstration and hands-on production of *Gynura procumbens* based functional cookies. Participants were directly involved in the production process, which included preparation of ingredients, weighing and formulation, dough preparation and mixing, cookie shaping, hygienic food handling, baking, and packaging. Household-scale appropriate technology was introduced to facilitate more standardized production, including digital weighing equipment, a mixer, an oven, and sealing equipment. The production process followed standardized procedures used during the training. Food hygiene and sanitation were reinforced throughout ingredient preparation, processing, baking, and packaging.

Assistance was provided during the practical session. Facilitators observed participants while they performed each production step and provided assistance on individual or small-group when difficulties occurred in ingredient preparation, operation of equipment, application of hygienic procedures, or completion of the production process. Practical performance was assessed through direct observation with the production procedure and SOP-based rubric as references. The observation focused on participants' completion of the supervised production stages, including ingredient preparation and weighing, dough preparation and mixing, cookie shaping, hygienic handling, baking, and packaging. The available documentation did not include individual numerical scores, formal competency classifications, or systematic records of the level of assistance required at each stage; therefore, the practical outcome was interpreted as completion of supervised production practice rather than evidence of independent competency.

The practical component was enhanced by introductory entrepreneurship and digital-marketing activities. Participants were introduced to simple production-cost calculation, determination of selling prices, product packaging and branding, and basic digital promotion through WhatsApp Business and Instagram. These activities were intended as an initial introduction to product development rather than as evidence of established business performance. Consequently, outcomes such as sales, revenue, profit, and longer-term economic improvement were not included as immediate measures of program success.

Outcome Measurement and Evaluation Instruments

Program evaluation focused primarily on two immediate outcomes: participant knowledge and practical production capacity. Knowledge was measured before and after the program using the same 10-item questionnaire. The instrument assessed knowledge related to diabetes and its prevention as well as functional-food concepts and hygienic food processing. The total knowledge score ranged from 0 to 10 and was categorized according to the program evaluation criteria as good (8–10), moderate (5–7), or poor (0–4). Scores were also converted into percentages for interpretation purposes.

All 12 participants completed the pre-test assessment as a baseline, in which complete and matching pre-test and post-test were available only for seven participants. Therefore, changes in knowledge were evaluated only among these seven participants by comparing their individual pre-test and post-test scores. This approach ensured that the observed changes represented within participant differences before and after the program and avoided comparisons between groups with different participant compositions.

Practical achievement was monitored through direct observation throughout the training. The facilitator team observed participant involvement in ingredient preparation and weighing, dough preparation and mixing, cookies shaping hygienic handling, backing, and packaging. The production procedure and SOP-based rubric were used as observational references rather than as a formal individual competency scoring instrument. The available program documentation mainly recorded completion of supervised production stages and facilitator observations. Therefore, the practical outcome was interpreted as evidence of participation in supervised production practice, rather than independent production competency.

In addition to participant evaluation, an initial consumer acceptability assessment of the functional cookies was conducted separately among 17 respondents who were not included in the pre-test and post-test knowledge evaluation. Six product attributes were evaluated: aroma, color, taste, texture, appearance, and portion size. Frequencies and percentages of positive responses were recorded for each attribute, while open-ended comments were used to identify areas for further product improvement. This evaluation was intended to provide preliminary feedback on the product and did not constitute a standardized sensory or commercial market test.

Monitoring and Follow-Up

Continuous monitoring was conducted throughout the educational and practical activities. Facilitators observed participant engagement, interactions during education, operation of processing equipment, adherence to hygienic procedures, and participation in cookie production. Difficulties identified during implementation were addressed immediately through demonstrations, individual guidance, and peer-coaching.

At the end of the activity, a follow-up discussion was done with community partners regarding continued cookie production, product quality improvement, packaging, entrepreneurship development, and digital promotion. As a result, a preliminary sustainability plan proposed; longer term outcomes such as independent production, continuity of marketing activities, product sales, and economic benefits were beyond the scope of the evaluation.

Data Analysis

Participant characteristics and program outcomes were analyzed descriptively. Age was summarized using mean, standard deviation, and range, while educational characteristics were presented as frequencies and percentages. Baseline and post-program knowledge scores were summarized using means, standard deviations, medians, minimum and maximum values, frequencies, and percentages. Baseline knowledge scores were summarized for all 12 participants using means, standard deviations, medians, minimum and maximum values, frequencies, and percentages. Post-program knowledge scores and pre-test–post-test changes were analyzed only for the seven participants with complete matched data. Descriptive analysis of the overall baseline profile included all 12 participants.

Changes in knowledge were evaluated with complete and matched pre-test and post-test data from seven participants. The mean percentage-point change was calculated by comparing the post-test and pre-test knowledge scores among these same participants. Changes in the proportions classified as having good, moderate, and poor knowledge were also described. Because the purpose of the evaluation was to document immediate achievement of the community service program, the results were interpreted descriptively rather than as evidence of population-level or clinical effectiveness. Consumer-acceptability responses from the separate group of 17 respondents were summarized using frequencies and percentages for each evaluated product attribute.

3. RESULTS AND DISCUSSION

Results

Program implementation and participant characteristics

The community service program was implemented on July 10, 2026, in Sapanang Village, Binamu District, Jeneponto Regency, South Sulawesi. The activity involved 12 PKK members and community participants in the baseline assessment and main program. The number of participants was lower than the initial target of at least 20 participants, primarily because the timeline coincided with the agricultural harvest period and high community mobility. Nevertheless, all participants who attended were involved throughout the educational and supervised practical activities.

The mean age of the 12 participants was 36.42 ± 11.94 years, ranging from 16 to 54 years. Half of the participants had completed senior high school (50.0 percent), followed by junior high school (25.0 percent), bachelor's degree (16.7 percent), and master's degree (8.3 percent). These characteristics indicate that the program reached women and community members across productive adult age groups and different educational backgrounds. The participant characteristics are presented in Table 2.

Table 2. Characteristics of participants at baseline (n = 12)

Characteristics	n (%) / Mean ± SD
Age, years	36.42 ± 11.94
Range, years	16–54
Educational level	
Junior high school	3 (25.0)
Senior high school	6 (50.0)
Bachelor's degree	2 (16.7)
Master's degree	1 (8.3)

The activity began with preparatory discussion among the implementation team members, the Sapanang Village Government, and PKK representatives. This stage established an alignment regarding the program objectives, participant involvement, facilities, and priority needs related to diabetes prevention and functional-food development. Health education was subsequently delivered through interactive explanation, discussion, and question-and-answer sessions covering diabetes risk factors, symptoms, prevention, healthy dietary patterns, dietary fiber, functional foods, and the potential use of *Gynura procumbens* as a locally relevant herbal ingredient. Photographic documentation of the educational activity is presented as Figure 2.



Figure 2. Diabetes-prevention and functional-food education for PKK members and community participants

Changes in diabetes-prevention and functional-food knowledge

The baseline assessment revealed considerable variation in participants' knowledge. Among all 12 participants completing the pre-test, the mean knowledge score was 71.67 ± 22.50 percent, with scores ranging from 30 to 100 percent. Five participants (41.67 percent) were categorized as having good knowledge, five (41.67 percent) as having moderate knowledge, and two (16.66 percent) as having poor knowledge. 58.33 percent of participants initially remained in the moderate or poor knowledge categories.

Complete pre-test and post-test data were available for seven participants (Table 3). To ensure the knowledge change represented changes within the same individuals, outcome analysis was restricted to these matched participants. The mean knowledge score increased; from 74.29 percent before the program to 95.71 percent after the program, representing an improvement of 21.42 percentage points. The proportion of participants classified as having good knowledge increased from 57.1 to 100 percent, while no participants remained in the moderate or poor categories after the activity. Five participants showed higher post-test scores, while the remaining two participants maintained their maximum baseline score of 100 percent. No participant experienced a decline in score.

Table 3. Changes in knowledge among participants with complete pre-test and post-test data (n = 7)

Knowledge Indicator	Pre-Test	Post-Test	Gap
Mean knowledge score (%)	74.29	95.71	+21.42 percentage points
Good knowledge, n (%)	4 (57.1)	7 (100.0)	+42.9 percentage points
Moderate knowledge, n (%)	2 (28.6)	0 (0.0)	−28.6 percentage points
Poor knowledge, n (%)	1 (14.3)	0 (0.0)	−14.3 percentage points

At the post-test, all seven participants with complete paired data correctly answered items addressing diabetes risk factors and symptoms, healthy dietary patterns, the concept and benefits of functional foods, functional-cookie development, utilization of local food resources, and hygienic food processing. These results indicate that the program achieved its immediate educational objective, particularly for topics repeatedly reinforced through discussion and practical activities.

Hands-on production of a *Gynura procumbens* based functional-food cookie prototype

Following the educational session, participants joined a supervised hands-on training session to produce functional cookies containing *Gynura procumbens*. Participants were directly involved in ingredient preparation, weighing and formulation, dough preparation, cookie shaping, hygienic handling, baking, and packaging. Household scale appropriate technology including a digital scale, mixer, oven, and sealing equipment was introduced to support more standardized and hygienic processing. The product developed during the program was treated as a functional-food prototype for educational and development purposes. Its nutritional composition, bioactive-compound content, and physiological effects were not evaluated in this activity.

All 12 participants completed the supervised functional-cookie production practice, including ingredient preparation and weighing, dough preparation and mixing, cookie shaping, hygienic handling, baking, and packaging. Completion of these stages was documented through facilitator observation. Participants who experienced difficulties received direct mentoring and peer-coaching as needed. Because individual competency scores and stage-specific levels of assistance were not systematically documented, these findings represent completion of supervised production practice rather than independent production competency (Table 4). Photographic documentation of this component is shown in Figure 3.



Figure 3. Hands-on production of *Gynura procumbens* based functional cookies

Table 4. Observed stages of supervised *Gynura procumbens* based functional-cookie production practice

Observed Production Stages	Assessment Approach	Program-Level Finding
Ingredient preparation and weighing	Direct observation using production procedure/SOP as reference	Completed during supervised practice
Dough preparation and mixing	Direct observation using production procedure/SOP as reference	Completed during supervised practice
Cookie shaping	Direct observation using production procedure/SOP as reference	Completed during supervised practice
Hygienic handling	Direct observation using production procedure/SOP as reference	Completed during supervised practice
Baking	Direct observation using production procedure/SOP as reference	Completed during supervised practice
Packaging	Direct observation using production procedure/SOP as reference	Completed during supervised practice

The SOP-based rubric served as an observational reference. Individual numerical scores, formal competent/not-competent classifications, and stage-specific levels of assistance were not systematically documented.

Entrepreneurship, Digital Marketing, and Product Acceptability

The production training was complemented by introductory entrepreneurship and digital-marketing activities. Participants were introduced to simple production-cost calculation, determination of selling prices, packaging and branding, and product promotion through WhatsApp Business and Instagram. These activities were designed to provide an initial foundation for the further development of women-led productive activities rather than to demonstrate immediate economic outcomes.

An initial product-acceptability evaluation was also conducted separately among 17 respondents. Six attributes were assessed: aroma, color, taste, texture, appearance, and portion size. Positive responses

were obtained from all respondents for aroma, taste, texture, and appearance. Positive evaluations were also recorded for color by 15 respondents (88.2 percent) and portion size by 16 respondents (94.1 percent), as presented in Table 5.

Table 5. Initial consumer acceptability of *Gynura procumbens* based functional cookies (n = 17)

Product Attribute	Positive Response (n)	Percentage (%)
Aroma	17	100.0
Color	15	88.2
Taste	17	100.0
Texture	17	100.0
Appearance	17	100.0
Portion size	16	94.1

Although the cookies were generally well accepted, the feedbacks identified opportunities for product refinement. Two respondents considered the product color less attractive, while one considered the portion size could be increased. Open-ended feedback also suggested providing additional topping variations. These findings provide practical directions for subsequent product development rather than evidence of formal consumer-market acceptance. Photographic documentation of entrepreneurship and packaging activities is presented in Figure 4.



Figure 4. Entrepreneurship, packaging, and digital-marketing activities for functional-cookie development

Monitoring, Challenges, and Immediate Program Achievements

Monitoring was performed throughout the activity by observing participant engagement, interaction during education, adherence to hygienic procedures, use of processing equipment, and participation in cookie production. Difficulties encountered by participants were addressed immediately through direct assistance and peer-coaching.

Several implementation challenges were identified. First, only 12 of the targeted 20 participants attended because of community mobility and the agricultural harvest period. Second, the limited sound system at the venue initially affected verbal communication, which was addressed by rearranging participants closer to facilitators and adopting more personalized interaction. Third, only seven participants had complete and matched post-test data. As a consequence, pre-test and post-test evaluation was restricted to these seven participants rather than comparing the full pre-test group with a different post-test group.

Overall, the success of the program included improved diabetes-prevention and functional-food knowledge, successful completion of supervised functional-cookie production by participants,

introduction of appropriate household-scale production technology, initial exposure to entrepreneurship and digital marketing, and favorable preliminary consumer feedback. These achievements represent short-term capacity-building outcomes and should not be interpreted as evidence of reduced diabetes incidence, improved metabolic outcomes, sustained independent production, or increased household income.

Discussion

Community participation and diabetes-prevention education

The improvement in participants' knowledge supports participatory education as an appropriate strategy for community-based diabetes prevention. The 21.42 percentage-point increase in mean knowledge score among matched participants is particularly relevant because the program combined education with active discussion and practical application. Participants connected diabetes-prevention concepts with food selection and functional-food production. This participatory approach can strengthen community agency, engagement, and ownership by enabling participants to interpret and apply information within their own context rather than simply receiving it passively (Wagemakers et al., 2025).

The findings are also consistent with (Fottrell et al., 2025), who reported substantial improvements in diabetes-related knowledge following a Participatory Learning and Action intervention delivered through community groups in rural Bangladesh. Similarly, the EMPOWER-D trial protocol applies community-based participatory learning and action as strategy for the prevention and control of type 2 diabetes, further demonstrating (Rehman et al., 2025b) the relevance of participatory approach in community diabetes programs (Rehman et al., 2025a).

The improvement observed, however, should be interpreted solely as an educational outcome. It does not demonstrate reduced diabetes risk or improved clinical outcomes. Community empowerment programs commonly produce changes first in knowledge, practical skills, confidence, and participation. Whereas behavioral, metabolic, and economic outcomes require longer periods of implementation and follow-up. This notable distinction is particularly important for the present program as the evaluation was conducted immediately after the intervention and complete paired data were available for only seven participants.

Integration of education with hands-on functional-food production

An important contribution of the program was the integration of health education with direct food-production experience. Knowledge and practical competence represent different dimensions of community capacity. Participants may understand the principles of healthier dietary practices, but direct experience is necessary to gain confidence in measuring ingredients, operating processing equipment, applying hygienic procedures, and producing a standardized food product. Experiential learning supports the development of health literacy and preventive competencies by actively involving participants in the learning process (Auld et al., 2020).

The use of a functional-food product also provided a tangible connection between preventive health education and local productive activities. Similar community-service initiatives have also demonstrated the value of transforming local resources into functional-food products through training and mentoring. For example, Juwita et al. (2025) reported that functional-food innovation through starfruit kombucha training increased processing skills among PKK members while also generated strong interest in independent production and marketing. Although the product and community context differed, both

programs demonstrate how practical food innovation can serve simultaneously as a capacity-building activity and a potential entry point for community economic development.

In this program, *Gynura procumbens* was particularly relevant because of its familiarity as a medicinal plant and its potential as a functional-food ingredient. Experimental studies have identified bioactive constituents and reported antioxidant and antiglycemic properties of *Gynura procumbens* (Ahmed & Shehu, 2022; Bose et al., 2025; Dewatisari et al., 2025; Situmorang et al., 2025). Nevertheless, these findings should not be translated directly into clinical claims regarding the cookies produced during the program. The product was therefore introduced as a functional-food innovation and educational medium rather than as a therapeutic intervention proven to prevent or treat diabetes. Nutritional composition, safety, shelf life, standardized formulation, and further product testing remain necessary before broader health or commercialization claims can be made.

Accordingly, the term "functional food" in this study refers to the product-development concept rather than to a validated physiological function of the cookies. Although *Gynura procumbens* has been reported to contain bioactive constituents and to exhibit antioxidant and antiglycemic activities in experimental studies, the cookies produced in this program were not analyzed for nutritional composition, bioactive-compound content, or physiological effects. Therefore, no claims regarding glycemic control, diabetes prevention, or other metabolic benefits can be made from the present findings.

Appropriate technology and productive capacity

The introduction of simple household-scale technology represents another practical contribution of the program. Digital weighing equipment, mixers, ovens, sealing equipment, and standardized procedures can improve consistency and hygiene while remaining accessible for community-level production. Importantly, apart from providing equipment, participants were also directly introduced to its use during the production process.

This strategy is consistent with community empowerment principles in which technology application is most useful when combined with training, mentoring, and community participation. Hurd & Stanton (2023) emphasized that community-driven programs are more likely to support sustainable capacity building when technical assistance and practical engagement accompany community participation. The present findings therefore suggest that appropriate technology can serve as a bridge between health-oriented innovation and productive skills, but continued mentoring is required before supervised training can develop into independent community production.

The current outcome completion of a supervised production simulation should consequently be regarded as an initial competency, not evidence of mastery or sustainable commercial production. Future evaluations should assess whether participants can independently reproduce standardized cookies without facilitator assistance, comply consistently with food-safety procedures, maintain product quality across production batches, and appropriately document production costs.

Entrepreneurship, digital marketing, and product development

The entrepreneurship and digital-marketing components expanded the program beyond health education by introducing participants to the potential pathway from product production to community-based enterprise. This was particularly suited for PKK members because community service programs involving women's groups frequently combine practical production skills with marketing and business capacity. Sasora et al. (2024), for example, reported improved understanding of digital marketing communication among PKK members following socialization, practical training, and mentoring, supporting the relevance of integrating digital-marketing skills into community-based women's

empowerment programs. Nevertheless, the present activity provided only introductory entrepreneurship and digital-marketing exposure.

No data were collected on actual product sales, revenue, profit, online reach, or sustained business operation. Therefore, the contribution of these components should be described as establishing an initial foundation for economic empowerment, rather than to be generalized that women's economic resilience had already improved (Hikmah & Nartin, 2025). Moreover, the present activity provided only introductory entrepreneurship and digital-marketing exposure. No data were collected on actual product sales, revenue, profit, online reach, or sustained business operation. Therefore, the contribution of these components should be described as establishing an initial foundation for economic empowerment, rather than as evidence that women's economic resilience had already improved. Long-term evaluation should assess independent production, continuity of online promotion, product sales, financial management, and economic benefits to the women's group.

The preliminary acceptability findings also provide an important basis for further product development. High positive responses for aroma, taste, texture, and appearance suggest that incorporating *Gynura procumbens* into cookies was acceptable within this small initial evaluation. However, color and portion size were identified as areas requiring refinement. Consumer acceptability is critical since even a product developed from potentially beneficial ingredients could be unlikely to be adopted if its sensory characteristics are undesirable. These findings therefore justify iterative formulation, standardized sensory evaluation, nutritional testing, food-safety assessment, and shelf-life testing before larger-scale dissemination.

Program contribution, limitations, and sustainability

Taken together, the program demonstrates the potential value of integrating health literacy, experiential food-production training, appropriate technology, and introductory entrepreneurship within a single women-centered community empowerment model. Rather than treating diabetes education and economic empowerment as separate activities, the program integrated preventive health information with a practical product that could be independently produced. This integration represents the principal innovation and community-service contribution of the program.

The interpretation of these findings must nevertheless consider several limitations. The number of participants was small and below the original target; only seven participants provided complete matched pre-test and post-test data; post-program evaluation measured immediate rather than sustained outcomes; and the practical assessment primarily documented successful supervised task completion rather than independent competency. Furthermore, consumer acceptability was assessed in only 17 respondents and should be regarded as preliminary. These limitations mean that the results are most appropriately interpreted as evidence of feasibility and initial capacity building, rather than proof of long-term behavioral, clinical, or economic effectiveness.

The outcomes of the program can be distinguished in relevance to the provided timeline. Immediate outcomes included improved diabetes-prevention and functional-food knowledge, completion of supervised functional-cookie production practice, and initial exposure to packaging, entrepreneurship, and digital marketing. Intermediate outcomes, which were not assessed in the present program, include participants' ability to independently reproduce the product, maintain consistent product quality, continue digital-marketing activities, and generate actual product sales. Long-term outcomes would include sustained income generation, development of a women-led community enterprise, and broader dissemination of health-promotion messages within the community. These intermediate and long-term outcomes should therefore be regarded as future program targets rather than demonstrated achievements of the current intervention.

Sustainability will require periodic mentoring, standardized production procedures, improvement of packaging and digital marketing, food safety and shelf-life evaluation, relevant licensing and halal certification, and further development of community-based business management. Sustained technical assistance and continued community involvement are particularly important when community programs are expected to progress from short-term training toward independent local capacity (Kotturi et al., 2024). Future community-service activities should therefore evaluate not only knowledge retention but also independent cookie production, adherence to standardized procedures, dissemination of diabetes-prevention messages by participants, continuity of digital marketing, actual product sales, and economic benefits generated for the women's group.

4. CONCLUSION AND RECOMMENDATION

The community service program integrating diabetes-prevention education with hands-on production of *Gynura procumbens* based functional cookies improved participants' knowledge and practical capacity. Among participants with complete paired data, the mean knowledge score increased from 74.29 to 95.71 percent, and all participants completing the final evaluation achieved the good-knowledge category. Participants also completed the supervised cookie-production process, including ingredient preparation, processing, hygienic handling, and packaging, supported by household-scale appropriate technology. The program therefore achieved its immediate objectives of strengthening diabetes-prevention knowledge and introducing functional-food production skills as an initial foundation for women-led community activities.

These outcomes should be interpreted as short-term educational and capacity-building achievements rather than evidence of clinical diabetes prevention or sustained economic improvement. The immediate outcomes of the program were limited to knowledge improvement, completion of supervised production practice, and introductory exposure to packaging and digital marketing. Independent production, consistent product quality, continued marketing, actual sales, income generation, and development of a sustained women-led enterprise remain intermediate or long-term outcomes that require further follow-up.

Future community service programs should involve a larger number of participants, ensure complete pre-test and post-test follow-up, and extend monitoring beyond the immediate training period. Subsequent initiatives are encouraged to evaluate participants' ability to produce the cookies independently, applying consistent standardized production and food-safety procedures, and sustain packaging and digital-marketing activities. Further product development should include nutritional value analysis, food-safety and shelf-life testing, standardized sensory evaluation, packaging improvement, and preparation for relevant licensing and halal certification before wider commercialization. Future programs should also assess longer-term outcomes such as continuity of production, product sales, profitability, and economic benefits for women's groups, supported by collaboration with village authorities, health services, universities, food-technology experts, and local business stakeholders.

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