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Development and Evaluation of Local Snack-Based Complementary Foods for Toddlers Aged 12–23 Months: Nutritional Adequacy, Acceptability, and Cost Feasibility

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ABSTRACT

Screening data from 412 toddlers in the Tlogosari Wetan Community Health Center area in 2024 revealed a 9.7% prevalence of wasting, with 45% of cases occurring in children aged 12–23 months. Furthermore, 47.5% of toddlers in local supplementary feeding programs did not consume their full portions, primarily due to limited flavor variety and poor taste acceptability. This study aimed to develop and evaluate the nutritional adequacy, sensory acceptability, and cost feasibility of local snack-based complementary foods (CF) for toddlers aged 12–23 months. A five-stage Research and Development (R&D) design was employed, encompassing preliminary research, planning, product development, expert testing, and field testing. Sensory evaluation was conducted by six expert panelists using hedonic and hedonic quality tests. Field trials involved 26 toddlers to assess acceptance using the Comstock method for food residue analysis. Data were analyzed using Repeated Measures ANOVA and Fisher's Exact tests. Six CF menus were successfully developed, all meeting national nutritional standards, with an energy content of 229–275 kcal, protein 9–11.3 g, fat 11.2–17.2 g, and a protein-energy ratio (PER) of 13.8–16.4%. The "Finger Rice Stick & Tempe Pudding" menu achieved the highest hedonic score for texture and overall preference ($p = 0.009$). Toddler acceptance reached 87.2%, with intake levels ranging from 58.9% to 81.3% for energy and protein. Cost analysis indicated the products were affordable, with production costs ranging from IDR 4,330 to IDR 8,417 per menu. The developed local snack-based complementary foods are nutritionally adequate, organoleptically acceptable, and economically feasible. These findings suggest their potential for integration into community-level nutrition programs to support stunting and wasting prevention efforts.

Key Messages:

- The development of locally sourced, snack-based complementary foods utilizing affordable and culturally familiar ingredients has been demonstrated to meet national nutritional adequacy standards, exhibit high sensory acceptability among toddlers aged 12–23 months, and maintain economic feasibility for integration into community nutrition programs aimed at preventing wasting and stunting

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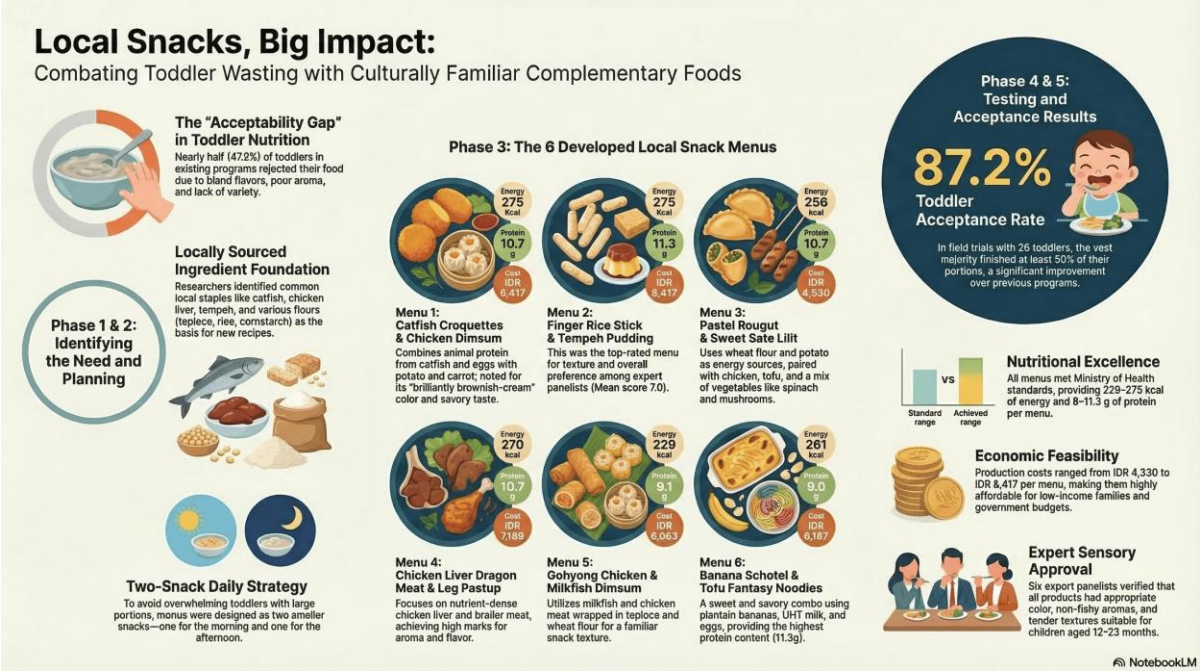
GRAPHICAL ABSTRACT



INTRODUCTION

The World Health Organization (WHO) and UNICEF emphasize that appropriate Complementary Feeding (CF), the timely introduction of safe, nutritionally adequate foods alongside breastfeeding, is essential for preventing undernutrition and promoting healthy development (1,2). In Indonesia, CF is regulated through Presidential Regulation No. 72 of 2021 concerning the Acceleration of Stunting Reduction, which sets a national target of 80% of children aged 6–23 months receiving proper CF by 2024 (3,4).

According to Indonesia's 2023 Health Survey (SKI), the prevalence of wasting among children under five increased from 7.7% in 2022 to 8.5% in 2024 (5). Screening of 412 toddlers in the Tlogosari Wetan Community Health Center area found 9.7% of them experiencing wasting, with 45% aged 12–23 months (6). Wasting is associated with higher risks of stunting, impaired cognitive development, and long-term non-communicable diseases (7). Early nutritional interventions during the first two years of life are therefore crucial to support optimal growth and brain development (8).

However, local data from the Tlogosari Wetan Community Health Center in 2024 revealed that 47.5% of toddlers who received food from Indonesia's government-supported Local Supplementary Feeding Program did not finish their portions. Mothers cited lack of variety in taste, unpleasant flavor, aroma issues, and excessive sweetness as the main reasons for poor acceptability. These findings highlight a need to develop locally sourced complementary foods that are nutritionally balanced, appealing, and culturally familiar (6).

While several studies in Indonesia have developed local CF recipes, few have incorporated cost analysis as part of product development. Cost evaluation is important to ensure program sustainability, affordability for low-income families, and feasibility for broader policy implementation. This gap provides the rationale for the present study. Therefore, this study aims to develop local snack-based complementary foods for toddlers aged 12–23 months that are acceptable, nutritionally adequate, and economically feasible.

METHODS

This study employed a Research and Development (R&D) design to produce and test the effectiveness of a locally based complementary feeding product (9). The R&D framework adopted from Borg and Gall (1989) originally includes six stages; however, this study applied five stages by combining

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the dissemination phase with the fieldtesting phase, as large-scale dissemination was beyond the project's scope. The five stages used were: (1) preliminary research and data collection, (2) planning, (3) product development, (4) expert testing, and (5) field testing (10).

Six expert panelists were involved in the sensory evaluation stage. The inclusion criteria for panelists were lecturers from the Nutrition Department who teach culinary nutrition and have experience in food product evaluation. They conducted hedonic and hedonic quality tests on the developed local snack-based complementary feeding (CF) products, assessing parameters such as color, aroma, texture, taste, and portion size. They conducted hedonic and hedonic quality tests on the developed local snack-based CF products, assessing parameters such as color, aroma, texture, taste, and portion size (11).

A total of 26 toddlers aged 12–23 months were enlisted as test subjects for the acceptance test of local complementary foods. The participation of toddlers was approved by their mothers and witnessed by Posyandu cadres, who served as community witnesses during data collection to ensure procedural compliance. The inclusion Criteria were toddlers in good general health, not suffering from acute illness, with no known food allergies or intolerances, and whose mothers provided informed consent (12).

The instrument used for the organoleptic test consisted of five parameters color, aroma, texture, taste, and portion size, assessed using a nine-point hedonic scale following the Indonesian National Standard (SNI 01-2346-2005) (13). The Comstock method instrument, which includes visual images representing food residue proportions (0%, 5%, 25%, 50%, 75%, and 100%) was used to assess the residue of local complementary foods and estimate actual food intake (14). The measurement was conducted visually by the mothers of toddlers at home, who had been previously trained by enumerators in the Comstock visual estimation technique, while Posyandu cadres acted as witnesses during data collection to ensure data validity and consistency. Measurements were performed by trained nutrition enumerators. A Repeated Measures ANOVA (RANOVA) test was used to analyze the hedonic and hedonic quality scores of the six types of complementary feeding (CF), and a Least Significant Difference (LSD) post hoc test was applied to identify specific differences between product pairs. Toddler acceptance data were analyzed with Fisher's Exact test.

CODE OF HEALTH ETHICS

This study has obtained Ethical Clearance from the Health Research Ethics Committee of the Semarang Ministry of Health Polytechnic, no. 550/EA/F.XXIII.38/2025.

RESULTS

The initial step in the research process is data collection.

A 2024 report from the Tlogosari Wetan Community Health Center showed that 47.5% of 116 toddlers who received local complementary feeding (CF) through the Local Supplementary Feeding Program did not finish their portions. Among those who did not finish their meals, mothers reported the following reasons: lack of flavor (15.8%), unpleasant taste (12.5%), undesirable aroma (12.5%), and excessive sweetness (6.7%). These findings indicate the need to develop CF with more appealing sensory characteristics to reduce food waste and improve toddler feeding practices. The preliminary assessment identified locally available food ingredients commonly used by mothers in the Tlogosari Wetan Community Health Center area for toddler meals (Table 1). These ingredients include carbohydrates, fats, animal protein, plant protein, and vitamin A from vegetables and fruits.

Table 1. Food ingredients commonly used by mothers of toddlers when preparing meals

Source of carbohydrates	Sources of Fat	Animal-Based Protein Sources	Plant-Based Protein Sources	Vitamin A Sources from Vegetables and Fruits
Noodles	Coconut Milk	Catfish	Tofu	Carrot
Rice	Margarine	Chicken	Tempeh	Green Beans
Rice Noodles	Sesame Oil	Shrimp		Broccoli
Potatoes	Palm Oil	Milkfish		Spinach
Cassava		Chicken Liver		Chayote
White Bread		UHT Milk		Plantain Banana
Breadcrumbs		Chicken Egg		Oyster Mushroom

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Source of carbohydrates	Sources of Fat	Animal-Based Protein Sources	Plant-Based Protein Sources	Vitamin A Sources from Vegetables and Fruits
Wheat Flour Rice Flour Tapioca Flour Cornstarch		Quail Egg Beef Meatball Broiler Chicken Meat Full Cream Milk Powder		Leek Wood Ear Mushroom

Table 1 lists the food ingredients used in making local complementary foods, in accordance with the 2025 technical guidelines for making complementary foods for toddlers, which state that complementary foods must be made from a variety of food sources, including carbohydrates, fats, animal proteins, plant proteins, and vitamin A from vegetables and fruits. PMT is made with standardized energy, protein, fat, and protein energy ratio (PER) content.

Planning

Based on experience, the preparation of toddler complementary foods in one snack results in the shape and portion being too large for one meal. Therefore, each menu of complementary foods needs to be designed with two snacks, one for the morning and one for the afternoon. At this stage, 12 local snacks were planned to compose six local snack CF menus. Table 2 presents the planned local complementary food menus for toddlers aged 12–23 months. Each menu combines two snack items (morning and afternoon) to meet appropriate portion sizes for toddlers.

Table 2. Menu Planning for Local Complementary Foods for Toddlers Aged 12–23 Months

Snack Menu	Carbohydrate Sources	Fat Sources	Animal-Based Protein Sources	Plant-Based Protein Sources	Vitamin A Sources from Vegetables and Fruits
Catfish Croquette	Potato, Wheat Flour, Bread Crumbs	Palm Oil	Catfish, Chicken Egg, Full Cream Milk Powder	Tofu	Carrot, Green Beans, Leek
Chicken Dumpling	Wheat Flour, Tapioca Flour	Palm Oil, Sesame Oil	Broiler Chicken Meat, Chicken Egg		Oyster Mushroom, Straw Mushroom
Finger Rice Stick	Rice, Tapioca Flour	Palm Oil	Broiler Chicken Meat, Chicken Egg, Shrimp		Carrot, Broccoli
Tempeh Pudding	Cornstarch	Coconut Milk	Chicken Egg, Milk Powder	Tempeh	
Bouquet Pastry	Wheat Flour, Potato	Palm Oil	Broiler Chicken Meat, Chicken Egg, Milk Powder	Tofu	Carrot, Leek
Sweet Satay Lilit	Potato, Cornstarch, Wheat Flour	Palm Oil, Margarine	Broiler Chicken Meat, Chicken Egg	Tofu	Carrot
Mini Meat Pastry	Cassava, Vermicelli	Palm Oil, Margarine	Beef	Tofu	Spinach, Carrot, Oyster Mushroom, Green Beans
Dragon Leg	Tapioca Flour, Bread Crumbs	Palm Oil	Chicken Liver, Broiler Chicken Meat, Chicken Egg		Carrot, Leek
Chicken Ball	Tapioca Flour, Wheat Flour	Palm Oil	Broiler Chicken Meat, Chicken Egg, Meatball	Tofu	Carrot, Chayote, Straw Mushroom
Scalloped Carang Gesing	Rice Flour, Bread, Wheat Flour	Coconut Milk	Chicken Egg, Milk Powder, UHT Milk		Raja Banana
Milkfish Dumpling	Wheat Flour, Tapioca Flour	Palm Oil, Sesame Oil	Milkfish, Chicken Egg	Tofu	Carrot, Chayote, Leek

The development of menus for complementary foods involves the use of local snacks and food ingredients that are easily available in the community and have good nutritional content. The balanced intake of energy, protein, fat, and carbohydrates in each menu is designed to meet the growth and development needs of children. Additionally, cost is a key factor to consider so that the product is affordable

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for people of all income levels. To provide an overview of the nutritional content and the cost per recipe or per serving, nutritional and price analyses of each menu item are provided. Table 3 shows the analysis of the macronutrient content and cost of producing local complementary food menus.

Table 3. Analysis of Macro Nutrient Values and Cost Analysis of Local Complementary Food Menus

Breast Milk Supplement Menu Lokal Snacks	Energy (Cal)	Protein (gr)	Fat (gr)	KH (gr)	Portion/ Resepe	Price / Resepe	Price / Portion	Price/menu
Catfish Croquettes &	140	5	8,4	11,2	16	Rp44.000	Rp2.750	Rp6.417
Chicken Dimsum	144	6	9,3	9,7	9	Rp33.000	Rp3.667	
Finger Rice stick &	139	6,2	10	5,8	10	Rp40.000	Rp4.000	Rp8.417
Tempe Pudding	136	5,1	4,8	18	12	Rp53.000	Rp4.417	
Pastel Rougut &	178	5,9	10	17,4	15	Rp34.000	Rp2.267	Rp4.330
Sweet Sate Lilit	99	5,5	7,2	3,4	16	Rp33.000	Rp2.063	
Chicken Liver Dragon Meat &	123	5,2	5,7	12,9	16	Rp85.000	Rp5.313	Rp7.188
Leg Pastup	147	5,5	9,3	10,6	24	Rp45.000	Rp1.875	
Gohyong Chicken &	129	5,5	7,5	9,8	30	Rp90.000	Rp3.000	Rp6.083
Milkfish Dimsum	132	3,6	3,9	21,6	12	Rp37.000	Rp3.083	
Banana Schotel &	100	6,4	3,7	10,9	9	Rp33.000	Rp3.667	Rp6.167
Tofu Fantasy Noodles	129	5,4	7,7	3,6	14	Rp35.000	Rp2.500	

Table 3 shows that the 6 CF menus of local snacks are in accordance with the standards for making PMT for Toddlers by the Ministry of Health of the Republic of Indonesia in 2024 (15). The analysis of macro nutrient values and cost of local snack-based breast milk supplements shows a variation in energy content ranging from 99 to 178 kcal per portion. Protein content is between 3.6–6.4 g, fat ranges from 3.7–10 g, and carbohydrate (KH) values vary from 3.4–21.6 g. Among the menus, *Pastel Bouquet* had the highest energy (178 kcal), while *Sweet Sate Lilit* had the lowest (99 kcal). In terms of protein, the highest was found in *Banana Schotel* (6.4 g), while the lowest was in *Milkfish Dimsum* (3.6 g).

A cost analysis indicated that the price per menu ranged between Rp4.330 and Rp8.417. The most economical snack was *the Pastel Bouquet (Rp4.330 per menu), while the most expensive was the Finger Rice Stick (Rp8.417 per* menu). This indicates that local snack-based menus are relatively affordable and can serve as alternative supplementary foods for breastfeeding mothers, with adequate macronutrient contributions at reasonable costs.

Initial Product Manufacturing

At this stage, 6 CF menus have been made for local snacks. Each creation of each menu is directly consulted by expert panelists to obtain evaluation and input to obtain a decent PMT Toddler product. The results of the improvement of the 6 CF local snack product are shown in Table 4.

Table 4. Energy, Protein, Fat, and Protein-Energy Ratio (PER) of Local Complementary Food Menus Compared with Standards

Characteristics	CF 1	CF 2	CF 3	CF 4	CF 5	CF 6
Standard Energy	225-275	225-275	225-275	225-275	225-275	225-275
Energy Complementary food given to breast milk	275	275	256,0	270	229	261
Standard Protein	4.5-11	4.5-11	4.5-11	4.5-11	4.5-11	4.5-11
Protein Complementary food given to breast milk	10,7	11,3	10,7	10,7	9,1	9
Satndard PER	10-16%	10-16%	10-16%	10-16%	10-16%	10-16%
PER Supplement for breast milk, local snack	15.6%	16.4%	16.7%	15.9%	15.9%	13.8%
Standard Fat	5.6-17.9	5.6-17.9	5.6-17.9	5.6-17.9	5.6-17.9	5.6-17.9
Complementary food given to breast milk	17,2	14,8	16	15	11,2	11,6

Table 4 shows that the 6 CF menus of local snacks made are in accordance with the standards for making PMT for toddlers by the Ministry of Health of the Republic of Indonesia in 2024 (16).

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Expert trial

At this stage, six local snack CF menus were tested using hedonic and hedonic quality tests by six expert panelists. Assessments were carried out on six organoleptic parameters, namely color, aroma, texture, taste, and overall impression. The results of the hedonic test are visualized in Figure 1.

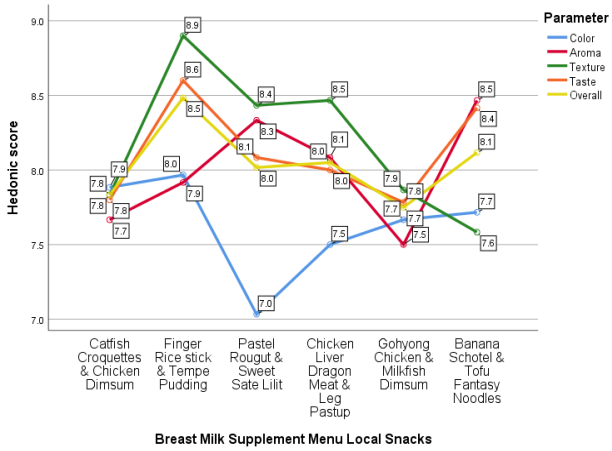

Figure 1. Results of CF Hedonic Test Local Snacks for Toddlers 12-23 Months

Figure 1 shows that the expert panelists generally liked all six local snack CF menus. The highest preference was shown in the color, texture, and flavor parameters for the *Finger Rice Stick & Tempeh Pudding menu*; on the aroma, texture, and flavor parameters for *Pastel Rougut & Sweet Sate Lilit* and *Chicken Liver Dragon Meat & Leg Pastup*; and on the aroma and flavor parameters for *Banana Schotel & Tofu Fantasi Mie*. The results of the hedonic test by expert panelists, analyzed using the Repeated Measure ANOVA, are presented in Table 5.

Table 5. Results of the CF Hedonic Test Local Snacks for Toddlers Aged 12-23 Months

Parameter	Breast Milk Complementary Food Menu Local Snacks																		p
	CF_1			CF_2			CF_3			CF_4			CF_5			CF_6			
	Mean	±	SD	Mean	±	SD	Mean	±	SD	Mean	±	SD	Mean	±	SD	Mean	±	SD	
Color	6,4	±	1,51	6,8	±	1,65	5,3	±	1,28	5,8	±	1,07	6,1	±	1,17	6,3	±	1,41	0,421
Aroma	6,1	±	1,27	6,3	±	0,99	6,8	±	0,63	6,4	±	0,61	5,8	±	1,03	7,1	±	0,89	0,101
Texture	6,2[a]	±	1,18	7,5[b]	±	0,50	6,8[b]	±	0,90	6,9[b]	±	0,79	6,2[a]	±	0,90	5,9[a]	±	1,10	0,078
Taste	6,2	±	0,99	7,2	±	0,85	6,4	±	1,34	6,4	±	0,84	6,1	±	0,79	6,8	±	0,48	0,390
Overall	6,2[a]	±	1,11	7,0[c]	±	0,80	6,3[a]	±	0,71	6,4[b]	±	0,76	6,0[a]	±	0,91	6,5[a]	±	0,80	0,009

CF_1=Catfish Croquettes & Chicken Dimsum, CF_2=Finger Rice stick & Tempe Pudding,
CF_3=Pastel Rougut & Sweet Sate Lilit, CF_4=Chicken Liver Dragon Meat & Leg Pastup,
CF_5=Gohyong Chicken & Dimsum Milkfish, CF_6=Banana Schotel and Tafami
p*= Repaeted Measure Anova (RANOVA) test
[a.b.c] = The same letter notation on 1 line means there is no real difference at alpha 0.05
Least Significant Difference (LSD) post hoc test

Table 5 shows that, in general, or according to the color, aroma, texture, and taste parameters of the Anova Repeated Measure (Ranova) test, there was no difference in hedonic scores among the 6 CF menus of local snacks (p=0.482). Thus, the expert panelists liked the six CF local snacks on all parameters.

Hedonic quality tests were conducted to assess the level of panelists' acceptance of various local menus accompanying breast milk based on color, aroma, texture, taste, and portion parameters. The results of the panelists' assessment are shown in Figure 2. The graph shows the variation in the hedonic score of each product, so it can comprehensively illustrate consumer preferences. Visually, the results of the hedonic quality test look like Figure 2.

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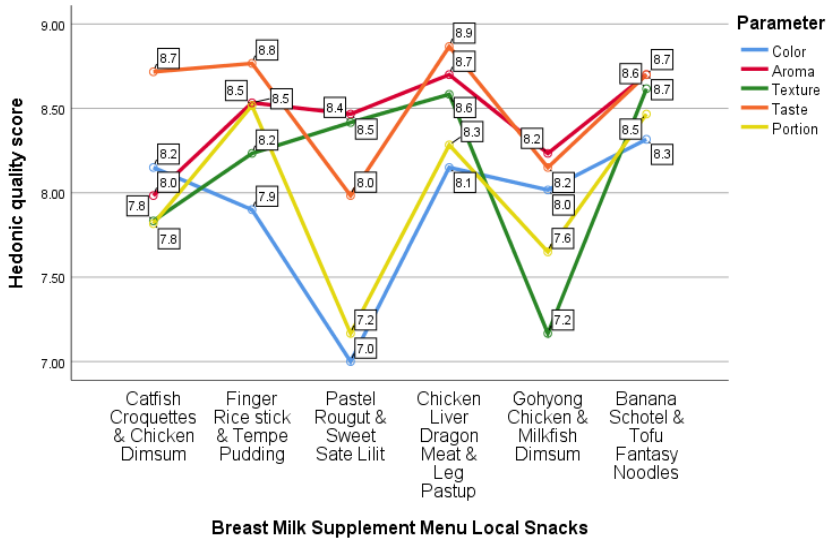

Figure 2. Hedonic Quality Results CF Local Snacks for Toddlers 12-23 Months

Figure 2 shows that, according to the expert panelists, the Catfish Croquettes & Chicken Dimsum menu is beautifully browned and cream-colored, has a non-fishy, slightly fragrant aroma, tastes good and savory, has a tender texture, and the portions are appropriate. The same goes for the Finger Rice stick & Tempe Pudding menu, the Chicken Liver Dragon Meat & Leg Paste menu, and the Banana Schotel & Tofu Fantasy Noodles menu. It is somewhat different from Pastel Rougut & Sweet Sate Lilit and Gohyong Ayam & Dimsum Milkfish, which, according to expert panelists, is a creamy brownish color and large portions are somewhat suitable, but the aroma is not fishy and somewhat musty, the texture is very tender, and the taste is delicious and savory. The results of the hedonic quality test of CF local snacks by 6 expert panelists using Repeated Measure Anova (Ranova) are shown in Table 6

Table 6. Results of Hedonic Quality Test CF Local Snacks for Toddlers Aged 12-23 Months

Parameter	Breast Milk Complementary Food Menu Local Snacks																		p
	CF_1			CF_2			CF_3			CF_4			CF_5			CF_6			
	Mean	±	SD	Mean	±	SD	Mean	±	SD	Mean	±	SD	Mean	±	SD	Mean	±	SD	
Color	8,2	±	0,93	7,9	±	0,88	7,0	±	1,63	8,2	±	1,29	8,0	±	0,58	8,3	±	0,72	0,310
Aroma	8,0	±	1,03	8,5	±	0,79	8,5	±	0,76	8,7	±	0,46	8,2	±	0,90	8,7	±	0,56	0,295
Texture	7,8	±	1,01	8,2	±	0,71	8,4	±	0,66	8,6	±	0,29	7,2	±	1,83	8,6	±	0,76	0,056
Taste	8,7	±	0,36	8,8	±	0,57	8,0	±	1,12	8,9	±	0,21	7,2a	±	1,29	8,7	±	0,56	0,216
Portion	7,8	±	1,09	8,5	±	1,18	7,2	±	1,17	8,3	±	1,21	7,2a	±	1,15	8,5	±	0,94	0,252
Overall	8,2a	±	0,67	8,5a	±	0,50	7,9a	±	0,87	8,6b	±	0,43	7,2a	±	0,83	8,7b	±	0,28	0,008

CF_1=Catfish Croquettes & Chicken Dimsum, CF_2=Finger Rice stick & Tempe Pudding,
CF_3=Pastel Rougut & Sweet Sate Lilit, CF_4=Chicken Liver Dragon Meat & Leg Pastup,
CF_5=Gohyong Chicken & Dimsum Milkfish, CF_6=Banana Schotel & Tofu Fantasy Noodles
p*= Repaeted Measure Anova (RANOVA) test
a.b.c = The same letter notation on 1 line means there is no real difference at alpha 0.05
Least Significant Difference (LSD) post hoc test

Table 6 shows that for all parameters there was no difference in hedonic quality score among the 6 CF menus of local snacks. For the six hedonic quality scores of the CF menu, the color hedonic quality score ranges from 7.0 to 8.3, the aroma hedonic quality score ranges from 8.0 to 8.7, the hedonic texture quality score ranges from 7.2 to 8.6, the taste hedonic quality score ranges from 7.2 to 8.8, and the hedonic portion quality score ranges from 7.2 to 8.5.

Field trials

Field trials were carried out to measure the acceptance of toddlers towards CF. The measurement of the receptivity of CF uses the Comstock method to measure the residual CF. The measurement of CF residue was carried out by 26 mothers of toddlers using a Comstock instrument with a picture of the

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remaining CF size, which had previously been taught how to fill in by enumerators. The results of measuring food waste and Energy, Protein, and fat intake are presented in tables 7 and 8.

Table 7. CF Local Snack Leftovers for 12-23 Months

Breast Milk Supplement Menu Local Snacks	Category (Comstock)		Total	p*
	Remnant (>50%)	Remnant (<=50%)		
Catfish Croquettes & Chicken Dimsum	5(19,2 %)	21(80.8 %)	26 (100%)	0.287
Finger Rice stick & Tempe Pudding	2 (92.3 %)	24 (92.3 %)	26 (100%)	
Pastel Rougut & Sweet Sate Lilit	4 (15.4 %)	22 (84.6 %)	26 (100%)	
Chicken Liver Dragon Meat & Leg Pastup	6 (23.1 %)	20 (76.9 %)	26 (100%)	
Gohyong Chicken & Milkfish Dimsum	2 (7.7 %)	24 (92.3 %)	26 (100%)	
Banana Schotel & Tofu Fantasy Noodles	1 (3.8 %)	25(96.2 %)	26 (100%)	
Total	20 (12.8 %)	136 (87.2 %)	156 (100%)	

*Fisher's Exact Test

Table 8. Energy, Protein, and Fat Intake Based on Food Waste and PER Protein Intake

Characteristic	Menu 1	Menu 2	Menu 3	Menu 4	Menu 5	Menu 6
Energy Complementary food to breast milk	275	275	256	270	229	261
Energy intake supplement for breastmilk, local snacks	162 (58.9%)	200 (72.7%)	173 (67.6%)	166 (6L5%)	185 (80.8%)	195 (74.7%)
Protein complementary food to breast milk	10,7	11,3	10,7	10,7	9,1	9
Protein intake supplement for breastmilk, local snacks	6.3 (58.9%)	8.2 (72.6%)	7.2 (67.3%)	6.6(61.7%)	7.4(81.3%)	6.7 (74.4%)
PER supplement for breastmilk, local snacks	15.6%	16.4%	16.7%	15.9%	15.9%	13.8%
PER asupan supplement for breast milk, local snacks	15.6%	16.4%	16.6%	15.9%	16.0%	13.7%
Fat Complementary foods to breast milk	17,2	14,8	16	15	11,2	11,6
Fat intake supplement for breastmilk, local snacks	10.1(58.7%)	10.8 (72.9%)	10.8 (67.5%)	9.2 (61.3%)	9.1(8L3%)	8.7 (75.0%)

DISCUSSION

This study developed and evaluated six snack-based Complementary Feeding (CF) menus using locally available ingredients for toddlers aged 12–23 months. The findings demonstrate that all menus met national nutritional standards, achieved high levels of acceptability among expert panelists and toddler consumers, and could be produced at relatively low cost. These results highlight the feasibility of community-based CF innovations that integrate nutritional adequacy, sensory acceptability, and cost considerations.

The positive reception of the developed CF menus underscores the importance of combining nutritional formulation with sensory and economic evaluations. Product success depends not only on nutrient content but also on taste, texture, aroma, portion size, and affordability. The absence of significant differences in hedonic and hedonic quality scores among the six menus (p>0.05) suggests that all products were formulated with similar nutrient profiles, ingredient proportions, and preparation methods, resulting in comparable sensory characteristics. From a cost-effectiveness perspective, the production price per menu (IDR 4.330–8.417) indicates that these local snack-based CF products offer good value for nutrient

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density and acceptability, making them economically feasible for community feeding programs with limited budgets. This integrated approach helps bridge the gap between dietary recommendations and actual feeding practices in the community setting (17). Product success depends not only on nutrient content but also on taste, texture, aroma, portion size, and affordability. This integrated approach helps bridge the gap between dietary recommendations and actual feeding practices in the community setting.

The findings are consistent with several studies published in the *Journal of Health and Nutrition Research*. Hassan and Mata (2024) reported that biscuits made from sorghum flour and anchovy meal were well accepted and nutritionally adequate for child feeding (18). Ratnawati and Satriani (2024) demonstrated that biscuits made from haruan fish flour and pumpkin improved the nutritional intake of toddlers (19). Sudiyanti (2023) found that Infant and Young Child Feeding (IYCF) interventions effectively improved the knowledge and attitudes of health cadres, which is crucial for successful community nutrition programs (20). Similarly, Palinggi et al. (2023) identified improved complementary feeding practices as a key factor in reducing stunting prevalence in Indonesian health centers (21). Together, these studies reinforce the value of local, culturally tailored nutrition solutions supported by community engagement and behavior change communication.

These findings also align with global frameworks established by the World Health Organization (WHO, 2023) and the United Nations Children's Fund (UNICEF, 2020), which emphasize that complementary feeding should be timely, nutritionally adequate, safe, and culturally appropriate. By integrating local food resources into evidence-based product development, this study operationalizes those principles within Indonesia's context. It also contributes to achieving Sustainable Development Goal (SDG) 2, which calls for ending all forms of malnutrition by 2030 through sustainable, community-driven approaches (1,2).

Implications for policy and practice. This research highlights the potential of local complementary foods to be integrated into government-supported programs such as Indonesia's Local Supplementary Feeding Program. Incorporating low-cost, high-acceptability local foods could optimize public spending and improve dietary quality for young children. Moreover, this participatory R&D model, combining technical expertise, community input, and cost analysis, offers a replicable framework for scaling up child nutrition interventions at the district and national levels. Strengthening collaboration between academic institutions, public health offices, and community groups could enhance both the efficiency and sustainability of complementary feeding initiatives.

International relevance beyond Indonesia, the approach demonstrated here has broader applicability in low- and middle-income countries (LMICs) facing similar challenges related to dietary diversity and affordability of commercial complementary foods. By prioritizing the use of local, nutrient-rich ingredients and engaging communities in product development, such models can reduce dependency on imported foods and promote local food system resilience. This aligns with the global shift toward sustainable, decolonized nutrition programming grounded in local innovation, cultural sensitivity, and evidence-based practice.

CONCLUSION

This research successfully engineered six distinct local snack-based complementary feeding (CF) menus tailored for toddlers aged 12–23 months, all of which strictly adhere to national nutritional standards. The developed products provide an energy content of 229–275 kcal, with protein (9–11.3 g) and fat (11.2–17.2 g) levels that yield a protein–energy ratio (PER) of 13.8–16.4%, meeting the standard requirements for this age group.

Expert sensory evaluations indicated high hedonic quality across all parameters, including taste, texture, and aroma, while field trials confirmed substantial toddler acceptance, with energy and protein intake reaching up to 80.8% and 81.3%, respectively. Given their nutritional adequacy, high organoleptic acceptability, and economic affordability (ranging from IDR 4,330 to IDR 8,417 per menu), these snacks represent a viable and sustainable alternative for enhancing toddler feeding practices.

The findings suggest that these formulations are economically feasible for potential integration into community-level nutrition programs. Future efforts should focus on evaluating the long-term

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nutritional impact of these products on child growth and facilitating their formal integration into government-supported supplementary feeding initiatives to enhance public health outcomes.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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