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From Parental Preferences to Product Design: Factors Shaping Nutritional Finger Foods for Early Childhood

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Abstract

This study explores the decision-making process of parents when purchasing healthy snacks for early childhood, emphasizing the need for snacks with complete nutritional benefits tailored to age, gender, and developmental stage. Insights from 371 parents at La-orutis Demonstration and Wat Amarindraram Schools in Bangkok, Thailand, revealed that the three main factors influencing their snack-purchasing decisions were nutrition, taste, and safety. In response, high-nutritional-value finger food (snack) formulations were developed, including: 1) a high-calcium formula, 2) an Omega-3 formula, and 3) a probiotic formula, using nutrient-dense ingredients such as brown rice flour (Aromatic Suphanburi), high-calcium milk powder, cheese powder, canola oil (for Omega-3), and *Bacillus coagulans* (for probiotics). The physico-chemical properties of all extruded snack samples were evaluated and compared to a control. Results indicated no significant differences in color (L*, a*, b*), expansion ratio, and water activity (a_w) among the fortified formulas and the control ($p>0.05$). However, significant differences were observed in inner and outer diameters, hardness, fracturability, moisture content, crude fat, protein, fiber, ash, total carbohydrates, and calcium levels ($p\leq0.05$). Notably, the calcium-enriched formula could be labeled as a "good source of calcium," while the Omega-3 and probiotic formulas showed enhanced levels of Omega-3 (5.03 g) and *Bacillus coagulans* viability (1.7×10^8 CFU/g), respectively.

Introduction

Healthy snacks play an essential role in children's diets, especially since the nutrients provided by main meals may not be sufficient to meet their daily requirements. Due to the limited capacity of their small stomachs, young children often cannot consume enough food in one sitting to sustain their energy and nutrient needs. Therefore, nutritious snacks are vital for ensuring they obtain additional energy and essential nutrients, which support both physical and cognitive development. Choosing appropriate snacks can also foster a positive relationship with a variety of foods, contributing to a happier, more engaged daily life (Jarasjiroj, 2016). Ideally, these snacks should provide at least two essential nutrients, such as protein, iron, calcium, vitamins A, C,

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B1, B2, or dietary fiber, and contribute at least 10% of the daily recommended nutrient intake.

A recent assessment by a Thai health organization found that 90% of snack samples from the Thai market, categorized into five groups (candy, gum, and jelly; chocolate; peanut and grain; fish snacks; and potato chips), contain high levels of sugar, sweeteners, sodium, and fat (Lomtakul, 2014). Frequent consumption of such low-nutrient, high-fat, and high-sugar snacks can contribute to overnutrition and related health issues in children (Iamopas et al., 2014). Therefore, selecting snacks that provide suitable energy and nutrition is essential to support optimal growth and development. Additionally, parents' purchasing decisions directly influence children's dietary habits, underscoring the importance of promoting healthy snacking behaviors.

To address these needs, certain ingredients can enhance the nutritional profile of snacks, including calcium-rich milk powder and cheese powder, canola oil (a source of Omega-3), and *Bacillus coagulans*, a spore-forming probiotic combined with fructo-oligosaccharide, a prebiotic. *Bacillus coagulans* has unique properties that allow it to survive the high temperatures of processing and resist digestive conditions, ensuring its effective delivery to the gut (Cao et al., 2020). This makes it particularly suitable for incorporation into dry snacks such as cookies and pasta, where other probiotics, like Lactobacillus and Bifidobacterium, cannot survive after heat treatment (Tripathi & Giri, 2014). The prebiotic fructo-oligosaccharide also supports immune modulation, mineral and lipid metabolism, and may reduce risks associated with metabolic syndrome and colon cancer (Wiater et al., 2020). Additionally, the formulation excludes monosodium glutamate (MSG) and preservatives and uses low-sodium salt.

The extrusion process—using high temperatures for short durations—preserves nutritional value while creating a puffed, crispy texture without the need for frying. This method is suitable for developing finger foods with enhanced nutritional profiles, particularly for young children's snacks.

The objective of this research is twofold: to understand the decision-making processes of parents when selecting snacks for young children and to develop nutritionally enhanced snacks. By incorporating ingredients such as powdered milk, cheese, probiotics, and Omega-3 and employing the extrusion process, this study aims to create lightweight, easy-to-store snacks suitable for various settings. Specifically, the research focuses on the following aspects: 1) understanding parental decision-making factors influencing snack choices, 2) selecting safe and nutritious raw materials, such as organic brown rice flour and rice bran oil, and 3) producing finger food snacks that support the developmental and nutritional needs of young children.

Materials and methods

1. Parental decision-making on snack purchases for early childhood

A survey was conducted to gather data on parents' behaviors, attitudes, and preferences regarding the purchase of bite-sized snacks for young children. Participants included parents from La-orutis Demonstration School (Bangkok, Suphanburi Campus, Nakhon Nayok Education Center, and Lampang Education Center) and Wat Amarindraram School (Bangkok) to promote nutrition and support snack choices for early childhood. Sample size determination was based on Yamane's (1967) formula with a 5% margin of error, resulting in a target sample of 371 out of a total population of 1,300. This included 263 parents from La-orutis Demonstration School and 108 from Wat Amarindraram School. Parents aged 18 to 60 completed a structured questionnaire in four parts: 1) demographic information, 2) snack purchasing behaviors, 3) product factors influencing snack choices, and 4) guidelines for developing nutritious bite-sized snacks.

2. Raw materials

The main ingredients used for snack development were carefully sourced for high nutritional quality. Aromatic brown rice (Hom Suphan cultivar) was procured directly from farmers in Suphanburi province, then milled, sieved to a 100-mesh size, and stored at -18°C before use. Corn grits (Thai Flour Mill Industry Co., Ltd., Thailand), milk powder (Dumex Dumilk 3, Danone specialized nutrition Co., Ltd, Thailand), and cheese powder (Ballantyne Foods Pty., Ltd., Australia) were obtained locally as calcium sources. Canola oil (Naturel, Lam soon public company limited, Thailand) for Omega-3 and *Bacillus coagulans* MTCC 5856 as a probiotic were acquired from commercial suppliers, while fructo-oligosaccharide syrup (Oligolite) was sourced from Eatwell Co., Ltd., Thailand. All reagents and solvents were of analytical grade.

3. Production of finger food (snack) products

Nutrient-enriched snack samples were prepared using

a twin-screw extruder (Hermann Berstorff Lab, Twin Screw Extruder ZE 25x33D, Nanjing Kerke Extrusion Equipment Co.,Ltd., China) based on a modified method from Yamprayoon (1996). The raw materials (as outlined in Table 1) were formulated and adjusted to a moisture content of 8-15% before extrusion. The extrusion conditions were set as follows: feeder screw speed at 870-900 rpm, die diameter at 28 mm, compression temperature at 155-160°C, and water feed pressure at 7 kg/cm², as shown in Fig 1.

4. Physico-chemical analyses

4.1 Physical qualities

Product diameter was measured using a vernier caliper, and the expansion ratio was calculated as the ratio of product diameter to the die diameter (Charunuch et al., 2003). Color attributes (L* for lightness, a* for redness, and b* for yellowness) were assessed using a HunterLab colorimeter (HunterLab model ColoFlex EZ, Color Global Co., Ltd., Thailand) following Karun et al. (2022). Hardness and brittleness (fracturability) were evaluated using a texture analyzer (TA. XT Plus, Stable Micro Systems, UK) based on Suksomboon et al. (2011).

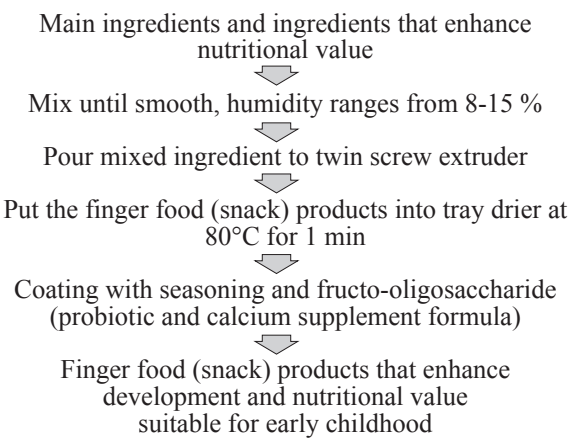

Fig. 1 The extrusion process of producing finger food (snack)

4.2 Water activity

Water activity (a_w) of extruded snack was measured using water activity meter (WA-160A, Guangzhou Amittari Instruments Co., Ltd., China). Prior to the measurement, the samples were tempered at 25°C. Two grams of powdered sample were weighed in plastic dish supplied with the instrument and subjected to instrumental measurement for aw (Yadav et al., 2018)

4.3 Chemical compositions

The moisture content was measured by air-oven methods according to AOAC Method 925.10 (AOAC, 2019). Crude protein was measured by a Kjeldahl method according to AOAC Method 992.15 (AOAC, 2019) using the conversion factor of 6.25 to convert nitrogen content to crude protein. Crude fat was measured according to AOAC Method 922.06 (AOAC, 2019) using a Soxtec apparatus and hexane as the solvent. Crude ash was determined by using AOAC Method 942.05 (AOAC, 2019). And then, total carbohydrates were calculated by 100 - (moisture (%) + fat (%) + Protein (%) + ash (%)). Crude fiber was measured according to AOAC Method 985.29 (AOAC, 2019) using a Fibertec apparatus. All chemical compositions were measured in duplicate.

Determination of calcium mineral content was conducted by using Atomic Absorption Spectroscopy (AAS) technique according to the modified method from Kangsdalampai and Sungpuang (1984). Fatty acid profile (FA) was determined by Gas Chromatography (GC)

Table 1 Percentage of importance marketing mix factors affecting the decision of parents in selecting snack

	Ingredients	Control Formula (g)	Formula 1 Calcium supplement (g)	Formula 2 Omega-3 (g)	Formula 3 Probiotic (g)
Extrudate	Brown rice flour (Hom Suphan)	1874	1874	1874	1874
	Corn grits	1956	1956	1956	1956
	Rice bran oil	128	128	-	128
	Canola oil	-	-	128	-
	Calcium carbonate	42	42	42	42
	High calcium milk powder	-	1372	-	-
Coating	Cheese powder	-	914	-	-
	Bacillus coagulans	-	-	-	425
	Fructo-oligosaccharide syrup	-	1714	-	3673
	Total	**4000**	**8000**	**4000**	**8098**

followed method of Lamas & Alvarez (2023). In brief, sample was weighed and mixed with hexane in a glass tube at concentration 1.0 mg/mL, following by adding 0.5 mL KOH/MeOH (2 mol/L). The mixture was vortexed for 1 min and NaCl (40% saturated solution) was added in the same volume as the hexane and vortexed for 10 sec. After allowing to stand for 5 min, the upper phase was used for injection in Shimadzu GC-2010 (Shimadzu corporation, Japan). FAMEs were determined using a flame ionization detector (260°C) and a capillary column (Omegawax 320, Darmstadt, Germany) with nitrogen as the carrier gas. External reference standards (Supelco FAME Mix C4-C24, Pennsylvania, USA) was used to identify peaks by comparing their retention times to each FA. Fatty acids were expressed as percentage of peak area to the total FAME area. Peak areas were quantified and FA were expressed as mg/100 g sample.

4.4 *Bacillus coagulans* quantity determination

The quantity of *Bacillus coagulans* (CFU/g) in probiotic formula was investigated according to the Notification of the Ministry of Public Health (No. 346) B.E 2555 (2012) Re: Use of Probiotic Microorganisms in Foods (No.2) by using PCR technique.

5. Statistical analysis

Experiments followed a Completely Randomized Design (CRD) and were repeated three times. Means were compared using Duncan's New Multiple Range Test (DMRT) at a 95% confidence level. Statistical analyses were conducted using IBM SPSS Statistics 19. For consumer behavior analysis, descriptive statistics described participant characteristics, while multivariable logistic regression evaluated factors such as taste, nutrition, shape, ease of consumption, price, texture, shelf life, safety, novelty, and quantity. Principal Components Analysis (PCA) was performed using Microsoft Excel 2007 and XLSTAT, with statistical significance set at $p \leq 0.05$.

Results and discussion

1. Parental decision-making on snack purchases for early childhood

The marketing analysis for young children's snacks (Innovation and Enterprise Department, 2023) reveals that more than 35% of early childhood children consume bite-sized snacks regularly, with this age group showing the highest consumption rates compared to others. This finding underscores the significant market for snacks targeted at young children, where purchasing decisions are largely influenced by parents. Key parental concerns include fostering healthy eating habits: 60% of parents prefer natural ingredients, 45% avoid artificial sweeteners, and flavor variety is a common secondary consideration. This market trend is shifting towards snacks made with natural ingredients, dietary fiber, and plant-based components. Packaging also plays an essential role in appeal, as parents prefer snacks that are easy to carry, have a long shelf-life, and clearly display ingredients.

The survey result was conducted to collect data on parents' behaviors, attitudes, and preferences regarding the purchase of bite-sized snacks for young children, as followed (Table 2).

Table 2 The parents and teachers' behaviors, attitudes, and desires for purchasing finger food (snack) for early childhood

	General information	La-orutis Demonstration School	Wat Amarintraram School
Gender		Percentage	
	Female	82.3	84.9
	Male	17.3	14.2
	Other	0.4	0.9
Age		Percentage	
	18-21 year	0.4	0.9
	22-29 year	2.1	18.9
	30-39 year	59.3	47.2
	40-49 year	34.6	30.2
	50-59 year	2.9	2.8
	Aged 60 year or over	0.7	-
Status		Percentage	
	Single	6.6	15.1
	Married	91.4	69.8
	Divorce	1.6	3.8
	Widowed	0.4	11.3
Education		Percentage	
	Junior High School	0.4	15.1
	Senior High School	3.7	40.6
	Bachelor degree	58.8	41.5
	Master degree and above	37	2.8
Occupation		Percentage	
	House husband/ House wife	10.3	11.3
	Government officer	22.2	25.5
	Employee	1.2	19.8
	Government enterprise	7.0	2.8
	Self-employed	38.8	15.1
	Private sector employee	17.7	14.2
	Other	2.8	11.3
Income		Percentage	
	Lower 10,000 Baht	2.5	14.2
	10,001-20,000 Baht	9.5	47.2
	20,001-30,000 Baht	18.5	28.3
	30,001-40,000 Baht	23.8	6.6
	More than 40,001 Baht	45.7	3.7

Table 2 (Cont.)

General information	La-orutis Demonstration School	Wat Amarintraram School
Relationship to the child	Percentage	
Father/Mother	96.3	92.9
Grandfather/Grandmother	1.6	5.9
Other	2.1	1.2
Number of members who are children	Percentage	
1-3	93.8	79.2
4-6	4.9	16.0
7-10	0.4	0.9
More than 10	0.9	3.8
Education level of early childhood	Frequency	
Kindergarten 1	67	26
Kindergarten 2	101	60
Kindergarten 3	87	25
Snack product purchasing behavior that affects the decision to buy snacks for pre-school children	La-orutis Demonstration School	Wat Amarintraram School
How often do you buy snacks for your pre-school children in one month?	Percentage	
less than 2 times	4.9	9.4
3-5 times	17.3	19.8
6-8 times	13.2	12.3
9-11 times	12.8	5.7
More than 12 times or more	51.9	52.8
What is the reason you want to buy snacks for pre-school children?	Percentage	
Buy it for your children to consume at home.	92	97
Buy it for your children to consume at school.	8	3
Where do you buy the most snacks for pre-school children?	Percentage	
Convenience store/mini mart	74.1	81.1
Mall	17.7	7.5
General grocery store	1.2	2.8
Flea market	0	4.7
Shop in/in front of school	5.8	3.8
Online channels	1.2	0
Snack product purchasing behavior that affects the decision to buy snacks for pre-school children	La-orutis Demonstration School	Watamarintraram School
How much do you spend on average in purchasing snacks each time? (Thai Baht (THB)) (EUR 1 = THB 38.084, USD 1 = THB 34.453)	Percentage	
20-30	14.8	30.2
31-40	10.3	9.4
41-50	22.6	17.9
51-60	8.6	6.6
61-70	5.3	6.6
> 71	28.3	29.2
Where does the information come from that you use to make decisions about purchasing snacks for pre-school children?	Percentage	
Early childhood	53.1	45.3
Child guardian	21.8	32.1
School teacher/professor	0.4	0
Internet	8.6	2.8

Table 2 (Cont.)

General information	La-orutis Demonstration School	Wat Amarintraram School
Advertisements on television	2.9	8.5
Offline advertising media such as setting up booths and inviting signs.	4.1	4.7
Promotion, discount, exchange, giveaway	3.3	2.8
Others	5.8	3.8
Snack product purchasing behavior that affects the decision to buy snacks for pre-school children	**La-orutis Demonstration School**	**Wat Amarintraram School**
What are the reasons you give preschoolers snacks?	Percentage	
Early childhood children do not consume enough staple foods	9.1	23.6
There are some nutrients that are beneficial to the body	10.7	15.0
Reduce the amount of time your stomach takes to empty between meals	54.3	34.0
Relieve stress during study	20.2	27.4
Other (please specify) nutritional value food diversity Experiment with different flavors	5.7	0
What time do you usually have pre-school children eat snacks?	Percentage	
During the trip to school	74.9	3.8
During the journey home from school	1.6	66
While reading/doing homework	9.9	7.5
While traveling/traveling	6.6	7.5
Guidelines for developing finger food (snack) products to enhance development and nutritional value for pre-school children	La-orutis Demonstration School	Wat Amarintraram School
What time do you usually have pre-school children eat snacks?	Percentage	
While playing games/watching television	3.7	10.4
Other (please specify) After meal or before meals	4.9	1.1
What is your behavior in purchasing snacks	Percentage	
Always buy unique snacks	1.2	3.8
Buy the same snacks regularly	18.9	2.8
Choose only brands that early childhood children like	39.9	16
Choose to buy snacks that are nutritious	30.5	45.3
Choose only the brands that early childhood children like	4.6	32.1
Other (please specify) Useful, does not contain ingredients that some young children are allergic to	4.9	0
What are the main factors that lead you to purchase a particular brand of snacks?	Percentage	
Price	3.7	13.2
Popular	46.1	4.7
Nutrition value	48.6	45.3
Taste	1.6	36.8
Have you ever bought nutritious finger food (snack) for pre-school children?	Percentage	
Yes	74.5	80.2
No	25.5	19.8

Table 2 (Cont.)

Guidelines for developing finger food (snack) products to enhance development and nutritional value for pre-school children	La-orutis Demonstration School	Wat Amarintraram School
Has your child ever eaten nutritious finger food (snack)?	Percentage	
Yes	75.3	80.2
No	24.7	19.8
If there was a new type of snack, a finger food (snack)product with more nutritional value, would you be interested?	Percentage	
Interested	87.7	84
Indifferent	10.7	16
Not interested	1.6	0
What characteristics do you think are important for nutritious finger food (snack)products for pre-school d children?	Frequency	
Taste	200	78
High nutritional value of raw materials	198	85
Product shape	65	24
Easy to eat	171	73
Price	110	67
Product texture such as crispness	64	20
Can be stored for a long time	52	29
Safety	169	76
Product novelty	50	17
The amount is appropriate for consumption	87	47
Quantity of nutritious finger food (snack) products for pre-school children that you are interested in purchasing (g)	Percentage	
30-40	33.1	51.9
41-50	26.4	20.2
51-60	26.8	
61-70	7.9	17.3
71-80	2.9	2.9
> 81	2.9	1.9
The price you would be willing to pay for 30 grams of nutritious finger food (snack) for pre-school children (Thai Baht (THB))	Percentage	
20-30	40	64.2
31-40	27.9	21.7
41-50	20.8	10.4
51-60	7.5	3.8
61-70	1.2	0
>71	2.5	0
The shape of nutritious finger food (snack) products for pre-school children that you are interested in purchasing.	Percentage	
Sphere	15.2	16
Rectangle	13.2	9.4
Square	3.7	3.8
Oval	9.9	13.2
Cartoon pattern	54.7	54.7
Other (please specify) any shape	3.3	2.9
What type of packaging do you think is appropriate for nutritious finger food (snack) products for pre-school children?	Percentage	
Opaque aluminum foil bag	13.4	15.2
Sealed plastic jar	23.4	26.7
Packaged in an envelope bag into a cardboard box	17.6	13.3
Kraft paper bag with foil inside	6.3	2.9
Clear plastic ziplock bag	15.1	21
Plastic coated paper zip lock bag	10	10.5
Foil ziplock bag	9.2	8.6
Other (please specify) Good for the e nvironment	5	1.8

1.1 Demographic information

The survey results on parents' snack purchasing decisions indicated that, for both La-orutis Demonstration School and Wat Amarintraram School, most respondents were female (82.3% and 84.9%, respectively) and in the 30–39 age range (59.3% and 47.2%). The majority were married (91.4% and 69.8%) with household incomes of over 40,001 Baht (45.7%) or 10,001–20,000 Baht (47.2%). Most respondents held a Bachelor's degree (58.8% and 41.5%), with 96.3% and 92.9% being the children's parents. Most children in the study were in kindergarten.

1.2 Snack purchasing behavior

The analysis of snack purchasing behavior (Table 2) showed that parents bought snacks for their children more than 12 times per month. The main reasons cited were to provide nourishment between meals, ease children's hunger, and manage mealtime routines at home. Convenience stores were the primary purchase location, with an average spend of over 70 Baht per purchase. Factors influencing snack choices included taste and nutritional content. As noted by Lomtakul (2014), snack quality was a top priority, with 80% of respondents rating it as "mostly to very important" (mean score: 6.42). Nutrition also ranked highly (mean score: 5.91), with nearly 70% rating this as a key factor. Parental choices were also significantly swayed by children's preferences (mean score: 5.86), indicating the strong influence children have on these decisions.

1.3 Product factors influencing snack choices

The results show that the 4Ps (Product, Price, Place, and Promotion) are key in parents' decision-making for early childhood snacks. Product attributes such as nutrition, taste, safety, and ease of consumption were the primary motivators, as shown in Fig 2. Conversely, factors like price, quantity, shape, texture, shelf life,

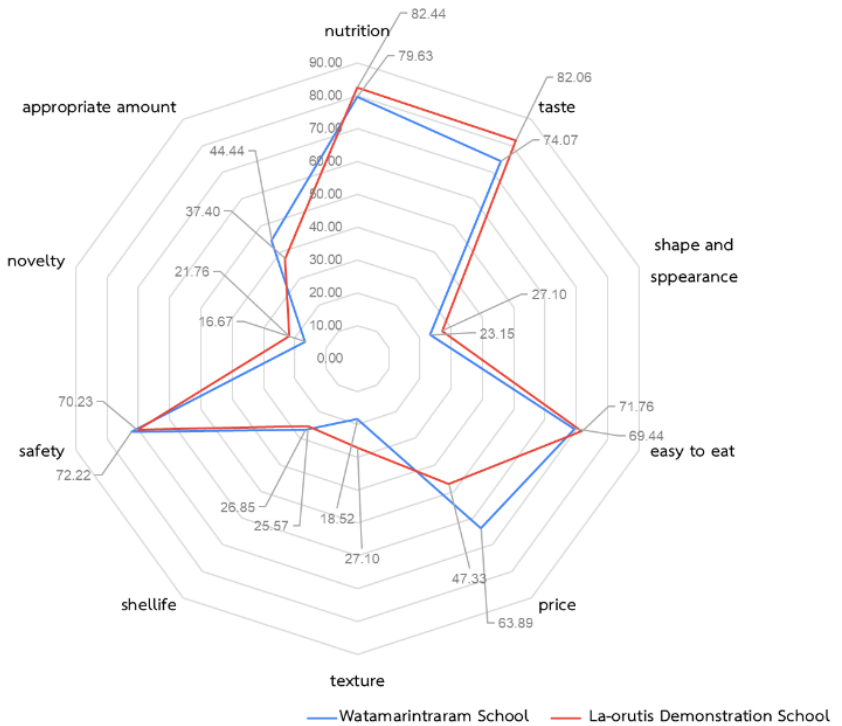

Fig. 2 Percentage of importance marketing mix factors affecting the decision of parents in selecting snack

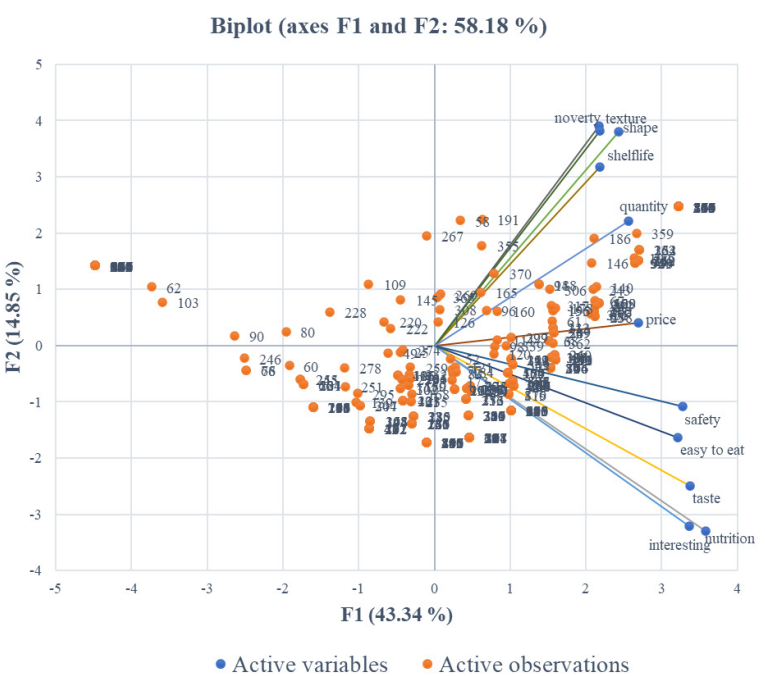

Fig. 3 Biplot of principal component analysis of important factors for early childhood finger food products

and novelty were considered less critical. Regression analysis confirmed that nutrition, taste, safety, and ease of eating were the primary drivers of purchasing decisions.

Principal Component Analysis (PCA) further clarified these findings (Fig. 3). Components 1 and 2 collectively explained 58.18% of the total variance, where component 1 was primarily related to price, quantity, shelf life, shape, and texture, and component 2 aligned with purchasing interest, nutritional value, taste, ease of eating, and safety. In particular, component 2 highlighted that parent's prioritized nutrition, taste, ease of consumption, and safety when selecting snacks for their children.

Regression model:
La-orutis Demonstration School: Y=1.137+0.402(X1) + 0.380(X2) + 0.070(X3) + 0.057(X4)
Note: R^2 =0.842: Y = parent's purchasing decision X1 = nutrition X2 = Taste X3 = safety X4 = easy to eat
Wat Amarintraram School: Y = 1.168+0.549(X1) + 0.201(X2) + 0.125(X3)
Note: R^2 =0.792: Y = parent's purchasing decision X1 = nutrition X2 = safety X3 = taste
La-orutis Demonstration School and Wat Amarintraram School:
Y = 1.157+ 0.470 (X1) + 0.297 (X2) + 0.119 (X3)
Note: R2 =0.811: Y = parent's purchasing decision X1 = nutrition X2 = Taste X3 = safety

1.4 Guidelines for developing finger food (snack) products to enhance early childhood nutrition and development

The study found that 74.5% and 80.2% of parents had previously purchased nutritional finger foods for early childhood children, and 75.3% and 80.2% reported that their children had consumed these products. Interest in nutritionally enhanced snacks was high among respondents, with 87.7% and 84% expressing interest in purchasing such products. The key characteristics parents valued in these snacks included taste, nutritional content of the ingredients, convenience, safety, and affordability. The preferred serving size for early childhood was 30-40 g, with a price range of 20-30 Baht per 30 g. Parents expressed a preference for cartoon-shaped snacks in sealed plastic jars, highlighting the appeal of engaging designs and practical packaging.

2. Production of finger food (snack)

2.1 Physical properties

The study developed finger foods aimed at enhancing early childhood nutrition and development using extrusion technology. Three formulations-calcium-enriched, Omega-3, and probiotic-were created according to Thai cereal snack standards (TIS 1534-2541). Key ingredients included powdered milk and cheese powder for calcium, canola oil with Omega-3 content (1,330 mg/15 mL), and *Bacillus coagulans* as a probiotic. No MSG or preservatives were added. The production process involved adjusting parameters on a twin-screw extruder, which influenced ingredient mixing and texture. Analysis of color properties (Hunter L*, a*, b*) showed no significant color differences among samples ($p>0.05$) (Table 3).

Table 3 Physical properties of finger food (snack) products

Physical properties	Control Formula	Formula 1 Calcium supplement	Formula 2 Omega-3	Formula 3 Probiotic
color				
L*^{ns}	79.69±0.57	80.85±0.01	81.62±0.02	80.81±0.01
a*^{ns}	4.89±0.06	5.75±0.01	4.34±0.01	4.58±0.06
b*^{ns}	35.79±0.05	35.55±0.04	34.13±0.02	31.77±0.01
Inner diameter (cm)	0.87^{a}+0.05	0.80^{b}±0.07	0.73^{c}±0.07	0.78^{b}±0.07
Outer diameter (cm)	2.37^{a}+0.11	2.34^{a}±1.08	2.08^{b}±0.05	2.09^{b}±0.14
Expansion rations	7.50+0.66	7.17+0.19	7.29+0.64	7.76+0.83
Hardness (g force)	3,561.00^{c}±1.00	5,917.02^{a}±1.73	2,838.00^{c}±1.40	4,077.00^{b}±1.73
Fracturability (mm distance)	7.72^{b}±0.01	8.05^{a}±0.04	7.81^{b}±0.02	8.64^{a}±0.02
a_w^{ns}	0.50±0.00	0.54±0.01	0.47±0.01	0.48±0.00

Remark: The letters a-c mean that the horizontal means are significantly different ($p\leq0.05$), The letters ns mean that the horizontal means are not significantly different ($p>0.05$)

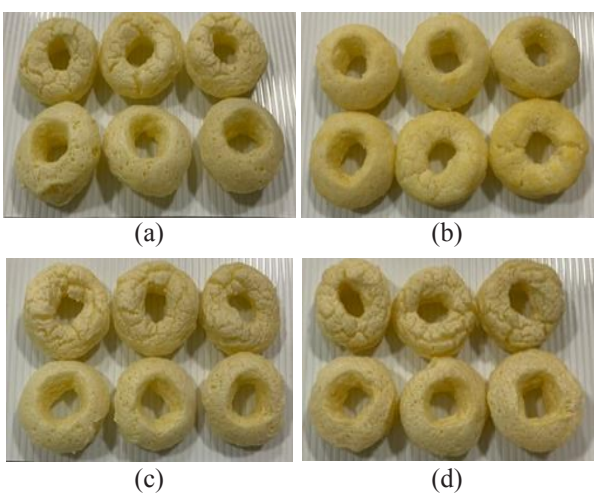

Fig. 4 The nutritionally enriched extruded finger food (snack) (a) control (b) calcium supplement (c) Omega-3 and (d) probiotic

2.2 Expansion ratio

Expansion is the consequence of several events involving both food material and process parameters. Although starch plays a major role in expansion, other ingredients (e.g., protein and lipids) act as diluents. (Aussanasuwannakul et al., 2022). The control formula had the highest expansion ratio, while the nutritionally enriched formulas exhibited lower expansion due to added ingredients (Fig. 4). Variations in inner diameter among the formulations were significant ($p \leq 0.05$); the control formula had the largest diameter, while the Omega-3 formula had the smallest. Outer diameter followed the same trend. These differences align with findings by Harper (1981a, 1981b,) and Suknark et al. (1997), who highlighted the impact of extrusion pressure and feed viscosity. As the snacks were adjusted to a consistent 15% moisture, moisture levels did not significantly impact expansion.

3. Chemical compositions

The results of the experiment found different chemical compositions in each formula depending on the raw ingredients that are important to enhance nutritional value. The Omega-3 formula was a source of Omega-3, 6, and 9. Fatty acid profile resulted revealed the total fat 5.29 g, the amount of Alpha Linolenic acid (5.03%), Linoleic acid (26.1%), and Oleic acid (52.71%). These resulted represent the total Omega 3, 6 and 9 fatty acids (5.03 g, 26.1 g, and 52.71 g, respectively). Thus, the extruded finger food (snack) can act as a potential medium for the delivery of health beneficial Omega-3 PUFAs to the early childhood. The calcium supplement formula was a source of calcium. It's increased in calcium content from 421±00 to 430±00 mg/100 g when compared to control. When calculating nutritional claims on labels using the criteria per serving size as reference and per serving size shown on the label of finger food (snack) products that promote development and nutritional value appropriate for early childhood using extrusion technology. The nutrient must be in the amount of 10-19% of the Thai RDI. For claims to be a calcium supplement, the nutrient must be in an amount not less than 10% of the Thai RDI. Calcium supplement formula, the calcium content of the Thai RDI is within the criteria specified for calcium content claims. ("Calcium supplemented", "A source of calcium", and "Contained calcium") which is in the range of 16.05% of the Thai RDI. Therefore, finger food (snack) products that promote development and nutritional value appropriate for early childhood with extrusion technology and calcium-fortified formulas can make nutritional claims on the labels such as: "Calcium supplemented", "A source of calcium", and "Contained calcium" (Bureau of Nutrition, 2020). The calcium supplemented formula and the omega 3 formula showed higher calcium content when compared to the control. This was due to the calcium contained in canola oil.

4. Viability of the probiotic *Bacillus coagulans* MTCC 5856

The probiotic formula was a source of *Bacillus coagulans*, which had up to 1.7 x 10^8 CFU/g. *Bacillus coagulans* is a gram-positive anaerobic bacterium that can produce lactic acid (Lee et al., 2019). It is heat resistant; the optimal growth temperature for *Bacillus coagulans* is 35 to 57°C and the optimal growth pH is 4 to 7 (Šipailiene & Petraityte, 2018). The amount of *Bacillus coagulans* counts in food has been reported between 10^6 to 10^9 CFU/g from several studies. Viability of *Bacillus coagulans* GBI- 30, 6086 in a wheat flour-based pasta after cooking processes was 10^9 CFU/100 g (Marcial-Coba et al., 2019). *Bacillus coagulans* MTCC 5856 was incorporated in series of foods and still obtaining counts above 10^7 CFU/g (Majeed et al., 2016). Moreover, Almada-Érix et al. (2022) proved that the probiotic *Bacillus coagulans* added to bread showed high resistance to the baking process and was above 10^7 CFU/g. In addition, when a spore-forming probiotic bacteria was sprayed into quinoa-based snack after extrusion process at 70°C under dry conditions, the viability after 120 days storage remained above 10^7 CFU/g (Muñoz et al. (2002). This study also suggested that in the production of symbiotic bread, an acceptable number of Ganeden BC30 (more than 10^6 CFU/g) was obtained even after storage for 3

Table 4 Chemical compositions and *Bacillus coagulans* content of finger food (snack) products

Chemical compositions	Control Formula	Formula 1 Calcium supplement	Formula 2 Omega-3	Formula 3 Probiotic
Moisture content (g/100 g)	7.38^{a}±0.16	5.77^{b}±1.17	3.28^{c}±0.03	5.32^{b}±0.07
Crude fat (g/100 g)	5.58^{b}±0.06	7.45^{a}±0.05	5.22^{c}±0.02	2.93^{d}±0.04
Crude protein (g/100 g)	7.88^{a}±0.01	7.64^{b}±0.02	7.60^{b}±0.10	4.73^{c}±0.02
Crude fiber (g/100 g)	4.77^{b}±0.06	3.77^{d}±0.02	3.99^{c}±0.01	5.38^{a}±0.02
Ash (g/100 g)	1.56^{c}±0.02	2.74^{a}±0.03	1.70^{b}±0.01	1.12^{d}±0.01
Total carbohydrates (g/100 g)	77.91^{c}±0.25	75.66^{d}±0.08	79.94^{b}±0.04	87.93^{a}±0.01
Calcium (mg/100 g)	421.00^{c}±1.00	430.00^{b}±2.00	456.67^{a}±0.58	301.67^{d}±1.15
Omega-3 (g)	-	-	5.03±0.04	-
Bacillus coagulans (CFU/g)	-	-	-	$1.7x10^{8}$

Remark: The letters a-d mean that the horizontal means are significantly different ($p \leq 0.05$), - not evaluated.

days at room temperature. Extrusion is a technique to transform starch and protein-based solid materials into a viscoelastic fluid under high pressure and temperature conditions without altering texture parameters (Li et al., 2019).

Conclusion

The decision-making process for purchasing healthy snacks, especially from the viewpoint of nutrition experts, emphasizes the importance of providing snacks with comprehensive nutritional value suitable for the age, gender, and life stage of the consumer. This is particularly crucial for early childhood, a period marked by rapid growth and increased energy and nutrient demands relative to body weight. Although children require three main meals a day, their smaller stomach capacity often limits meal portions. Nutritious snacks can therefore play a significant role in providing additional energy, supporting diverse food consumption, and adding joy to daily life. Our findings indicate that parents of early childhood children purchase snacks more than 12 times per month. Key factors influencing their buying decisions include taste, nutritional value, and safety, all of which greatly impact snack choices for young children. When it comes to developing finger food products that support early childhood growth and health, our research shows a high level of interest in nutritious snacks among parents, with an 84% preference for finger foods with enhanced nutritional value. The three top priorities for these snacks were: 1) taste, 2) high nutritional quality of ingredients, and 3) ease of consumption. Parents expressed a preference for snacks in cartoon-shaped, 30-40 g portions, priced at 20-30 Baht, and packaged in sealed plastic jars. Our product development efforts identified rice flour (Aromatic Suphanburi) as a suitable base ingredient, with nutrient-enhancing components like canola oil for the Omega-3 formula, *Bacillus coagulans* for the probiotic formula, and powdered milk and cheese powder for the calcium-fortified formula, yielding a calcium content of 14.29%. These finger foods show promising potential for addressing the specific nutritional needs of early childhood while meeting parental preferences for safety, convenience, and appeal.

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