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Gluten-free Pasta Products with Improved Nutritional Profile by Using Banana Flour

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Abstract This study aimed to determine an optimum formula for producing gluten-free pasta using banana flour. A mixture design experiment was conducted, and three factors were analyzed, 40-60% banana flour, 7-27% modified starch, and 23-43% water. The most appropriate formula included 40% banana flour, 27% modified starch, and 33% water. The nutritional profile of this gluten-free pasta per 100 grams was 469.29 kilocalories of total energy, 4.71 grams of protein, 7.60 grams of dietary fiber, 26.69 micrograms of vitamin A, 0.039 milligrams of vitamin B, 0.093 milligrams of vitamin B2, 60.30 milligrams of calcium, and 1.33 milligrams of iron. Further, these pasta products exhibited prebiotic properties and their overall preference score was at a moderate level of 7.02. Consequently, the gluten-free pasta made using banana flour differed from the commercial product due to its soft and flexible texture. Altogether, the pasta was nutritious and had prebiotic properties.

Keywords: *pasta, gluten-free, improve, banana flour, prebiotic*

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1. Introduction

Presently, healthy food products or functional foods have gained popularity for consumption. This might be due to the additional health benefits that these products offer in contrast to the existing core nutrients as food consumption is directly related to health. The American Dietetic Association considers functional foods as those in which the existing natural nutritional composition of the ingredients is maintained, those with an extra function owing to the addition of new ingredients, or those with surplus existing ingredients that offer health benefits, which could be consumed as part of the daily diet at an adequate amount for potential health benefits. Examples of functional foods are probiotics, prebiotics, cereals, dietary fibers, antioxidant substances, and phytochemicals [1]. Currently, healthy food markets are preferred by consumers worldwide, including Asia, North America, Europe, Latin America, Australia, and New Zealand. The sales volume in 2013 was projected to be US$ 90,500 (approximately 2,896,000 million baht). The major markets included the United States of America, followed by Japan and Europe [2]. Furthermore, the changes in people's livelihood and life in polluted environmental conditions have led to pronounced/severe symptoms of allergies, which tend to be increasing. As no cure is available for food allergies, consumers need to avoid eating allergic foods and read the information on food labels carefully and thoroughly to ensure they avoid foods with allergic ingredients. Once an individual has developed a food allergy, it is most important for him/her to be cautious.

Pasta products are part of the noodle family widely consumed in western and eastern countries. An integral component of pasta is the starchy carbohydrate. Pasta is popularly consumed in many countries as a staple meal; hence, its global consumption has increased. Therefore, it is promising to improve the nutritional value of pasta and develop it as a healthy food item. Generally, pasta is made from a coarsely ground high protein durum wheat called semolina flour [3], which is mixed with water and kneaded until a smooth dough is obtained. The dough is extruded into various shapes using an extruder. As wheat is the key component for the production of pasta, it involves low nutritional value, and consumers may be allergic to gluten protein in wheat. Gluten allergy symptoms have been observed in individuals across different age and sex groups; moreover, these symptoms vary with the different age groups. The only way to control these allergy symptoms is by eating gluten-free food items throughout life. Therefore, many studies have been conducted worldwide to develop gluten-free pasta products using rice flour instead of wheat flour. Rice flour is a gluten-free flour necessary to be added a stabilizer, a gum type that can be used as a substitute for gluten in wheat flour so as to improve the structure of rice flour pasta. Moreover, studies have been conducted on producing pasta from rice flour with modified starch or pregel rice flour as components, which have improved its characteristics, such as texture, softness, and chewiness, and stickiness [4].

In general, banana flour has specific aroma, taste, and attractive physical properties. Further, it combines very well with water. When being heated, it exhibits swelling and transparency patterns; upon being cooled, it is associated with the gelatinization characteristic. Additionally, banana flour contains a high level of amylase, which imparts it specific properties suitable for being cooked. Besides, banana flour is a healthy food ingredient, which is suitable for consumers who avoid wheat flour or are allergic to the proteins in it [5]. Banana flour contains prebiotic properties.

Consequently, we considered using banana flour to develop gluten-free pasta products as healthy foods with prebiotic properties, which offer a new alternative for consumers who are allergic to gluten. It is relevant as the likelihood of developing the allergy has apparently increased. Further, this will enhance the value of agricultural products. Therefore, the objective of this study was to examine a suitable formula for gluten-free pasta production from banana flour. In addition, the physical properties, nutritional profile, microbial composition, prebiotic properties, and sensory acceptance of the gluten-free pasta from banana flour were determined.

2. Materials and Methods

2.1. Preparation Banana Flour

Banana Flour from One Banana Co., Ltd. was procured. This flour is made from unripe banana varieties of *Musa sapientum* L., AAA group. The banana flour was analyzed to derive its chemical and physical qualities.

2.2. To Identify an Appropriate Formula for Gluten-free Pasta Production from Banana Flour

2.1.1. Evaluation of Banana Flour Quality

2.2.1.1. Chemical quality: The moisture content and nutritional profile were determined as per the prescribed method by AOAC [6].

2.2.1.2. Physical quality : The water activity (a_w) was measured using the water activity meter, Nobasina AG. The color was examined using a Lovibon SP60E colorimeter, and the swelling power (SP) and solubility were determined according to the method described by Schoch [7]. Banana flour (0.5 grams, db) was weighed directly into a centrifuge tube, and 15 milliliters distilled water was added to it. The SP and solubility of rice starch were determined at different temperatures (55, 65, 75, and 85 ℃) by incubating the centrifuge tube in a water bath for 30 minutes. Thereafter, the tube was centrifuged at 2,200 ×g for 15 minutes at 25 ℃. The supernatant was discarded, and the sediment was weighed. The supernatant for determining SP was dried to obtain a constant weight in a hot-air oven at 105 ℃. The SP and water solubility index of banana flour were calculated as described by Schoch [7].

2.2.2. To study the Appropriate Formula

The factors that were examined in this study included the amounts of banana flour, modified starch, and water. A mixture design method was used in the experiment. The basic formula is shown in Table 1, which was used to produce banana flour pasta according to the process shown in Figure 1.

Table 1. The basic recipe for producing pasta

Ingredients	Quantity (percentage)
Banana flour	40.00 – 60.00
Modified starch	7.00 - 14.00
Water	23.00 – 43.00
Guar gum	0.50
Olive oil	8.50
Egg yolk	8.50
Salt	0.50

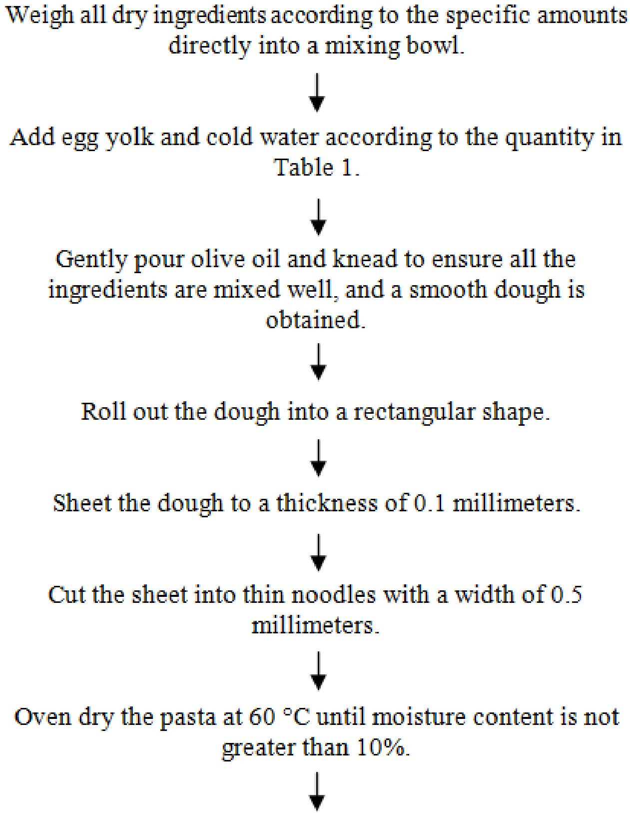

Figure 1. Production process of gluten-free pasta using banana flour

The obtained pasta was analyzed for quality as follows:

2.2.2.1 Physical quality: water activity (a_w) and color were measurement. The cutting and shearing force were measured using a texture analyzer (TA-XT2i) based on the method described by Dvorakova et al. [8] to compare the quality with that of the commercial products.

2.2.2.2 Sensory property: Preferences from 60 consumers were studied. Central Location Test (CLT) was performed using the 9-point hedonic scale. Written consent of a consumer was obtained prior to the test.

An appropriate formula was devised based on the preference scores and cutting and shearing force values comparison with those of commercial products (Control). Analysis of variance (ANOVA) was performed on the obtained data. In case of statistical significance, Duncan's new multiple range test (DMRT) was applied to test the difference of means.

2.3. Evaluation of the Quality of Gluten-free Pasta Made Using Banana Flour

The gluten-free pasta from banana flour was produced based on the appropriate formula derived from 1.2 and was analyzed for the following traits:

2.3.1 Physical quality: It was measured as discussed above (2.1)

2.3.2 Chemical quality [6].

2.3.3 Microbiology quality i.e., analysis of the total microorganisms, yeast and mold, and coliforms [6].

2.3.4 Prebiotic properties: These properties of the gluten-free pasta made using banana flour were determined by monitoring the growth of *Lactobacillus plantarum* DSM 2648 and *Escherichia coli* TISTR 8379.

2.3.4.1 Starter culture preparation

L. plantarum DSM 2648 and *E. coli* TISTR 8379 were cultured in MRS broth and Nutrient broth (Merck), respectively. These were incubated at 37℃ under anaerobic conditions for 24 hours and centrifuged at 3,000 revolutions per minute (rpm) for 10 minutes. Remove the transparent part and the cells were washed in 0.85% NaCl and centrifuged at 3,000 rpm for 10 minutes. This step was repeated and the starter cultures were obtained.

2.3.4.2 Preparation of culture media

We weighed 1% sample of the pasta dough made from banana flour (weight to volume), added basal medium and mixed well, adjusted the pH to 6.8, and sterilized the culture media.

2.3.4.3 Monitoring the growth of the starter cultures

Added 1 % *L. plantarum*, *E. coli*, and *L. plantarum* + *E. coli* into each culture media flask as described in Table 2.

Table 2. Addition of the tested starter cultures under different conditions

Flask no.	Starter cultures		Culture media	
	***Lactobacillus plantarum* DSM 2648**	***Escherichia coli* TISTR 8379**	**Basal Medium**	**Pasta dough made from banana flour**
1	√		√	
2	√		√	√
3		√	√	√
4	√	√	√	√

The cultures were incubated at 37 ℃ under anaerobic conditions, and samples were collected at 0, 4, 8, 12, 16, and 24 hours. The collected samples were diluted to appropriate levels of concentration. The plate count was recorded for *L. plantarum* DSM 2648 and *E. coli* TISTR 8379 using MRS and nutrient agar plates. The starter culture plates were incubated at 37℃ under anaerobic conditions.

2.3.5 Sensory quality assessment: This assessment was conducted to determine the preferences of 100 individuals (aged 20 years and over divided into 4 ranges, 25% each rang) who consumed pasta in tomato sauce with minced chicken. Central Location Test (CLT) was performed using the 9-point hedonic scale. Written consent was procured from a consumer prior to the test.

3. Results and Discussion

3.1. An Appropriate Recipe was Determined for Producing Gluten-free Pasta Using Banana Flour

3.1.1. Physicochemical Quality Assessment of the Obtained Banana Flour

The findings for the chemical and physical qualities of the obtained banana flour are presented in Table 3.

Table 3. Assessment of the chemical and physical qualities of the obtained banana flour

Qualities	Content	Unit (per 100 grams of sample)
Chemical qualities		
Moisture content	8.02	grams
Total energy	358.42	kilocalories
Energy from fat	7.02	kilocalories
Total fat	0.78	grams
Saturated fat	0.30	grams
Cholesterol	Not found	milligrams
Protein	4.30	grams
Carbohydrate	83.55	grams
Dietary fiber	5.43	grams
Total sugar	5.02	grams
Sodium	5.31	milligrams
Vitamin A (beta carotene)	Not found	micrograms
Vitamin B1	0.11	milligrams
Vitamin B2	0.05	milligrams
Calcium	16.67	milligrams
Iron	1.22	milligrams
A	3.35	grams
Physical qualities		
L*	69.19	
a*	1.30	
b*	1.09	
Swelling power		
At 55 ℃	23.66	grams/gram dry weight
At 65 ℃	30.32	grams/gram dry weight
At 75 ℃	56.39	grams/gram dry weight
At 85 ℃	78.82	grams/gram dry weight
Solubility of the flour		
At 55 ℃	13.20	dry weight percentage
At 65 ℃	13.24	dry weight percentage
At 75 ℃	13.55	dry weight percentage
At 85 ℃	13.65	dry weight percentage

As shown in Table 3, the chemical qualities included the moisture content and nutritional profile of the banana flour. The moisture content of the banana flour was 8.02 grams, which is consistent with that recommended by the Thai Agricultural Commodity and Food Standard (TACFS) number 0006-2548, which states that the flour moisture content should not exceed 12% weight. With respect to the nutritional profile, it was observed that 100 grams of the banana flour yielded 358.42 kilocalories of total energy, which included 7.02 kilocalories of energy from fats.

Furthermore, 83.55 grams of carbohydrates, 5.43 grams of dietary fiber, 4.30 grams of protein, 0.11 milligrams of Vitamin B1, 0.05 milligrams of Vitamin B2, 1.22 milligrams of iron, and 3.35 grams of ash were observed. These findings were consistent with those of a study conducted by Klanarong [9], which showed that banana flour made from finely ground raw materials consisted of nutrients, such as carbohydrates, proteins, fats, dietary fiber, and minerals. Banana is low in fat; however, it is rich in energy. Therefore, it is recommended for consumption by elderly and individuals with gastrointestinal diseases [10].

With reference to the color measurement, very high L* was observed which corresponded to the dark color of the banana flour (that is, light brown). In terms of the a* and b* values, those indicating red and yellow colors were low. The light brown color of the banana flour could be attributed to the enzymatic browning reaction [11].

SP and solubility of the banana flour were investigated at 55, 65, 75, and 85 ℃. The findings were consistent with those of a study conducted by Thasanee [12], which revealed that the SP and solubility increased with increasing temperature. The SP of starch depends on its amorphous and crystalline regions. An amorphous region has unorganized molecular arrangement via weak bonds, and it could be easily degraded; therefore, the swelling occurs early. In contrast, the crystalline region has strong molecular arrangement via strong bonds, and it could only be degraded at increased heat, which causes swelling. Moreover, a high of amylose in starch affects its SP. Banana flour has amylose content between 25.8 - 37.1% [13]. Banana flour was classified as a starch that there is a few complaints (restricted-swelling starches). In addition, the percentage of solubility and a swelling also correlated with the amylose content of each type of starch. Banana flour contain high amylose content. Therefore it has dissolved and low swelling power [14].

3.1.2. An Appropriate Formula was Devised

After mixture design method was applied for the experiment. There are 13 recipe that used to make pasta was shown in Figure 2 and Figure 3.

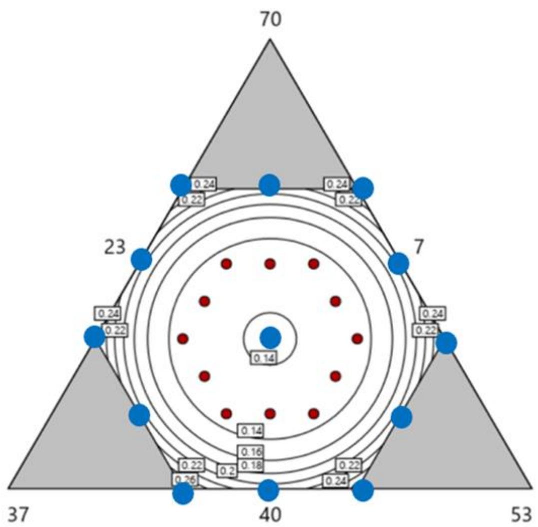

Figure 2. Various formulae for producing pasta using banana flour based on the mixture design method

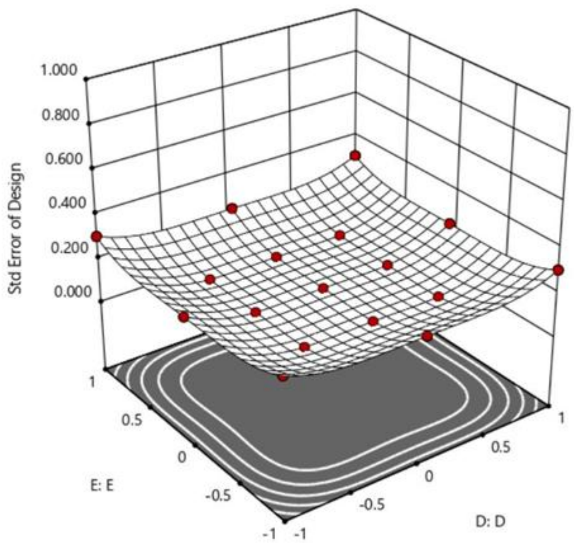

Figure 3. Three-dimensional image of the pasta produced from banana flour based on the mixture design method

Subsequently, 13 formulae were used to produce the banana flour pasta (based on Figure 2). The quality of pasta dough was analyzed, and the results indicated formula numbers 1, 2, 8, and 9 had a good characteristics as shown in Table 4.

Table 4. Characteristics of the pasta dough from formula 1, 2, 8 and 9

Recipe number	Illustration	Observations
1 (60% banana flour, 17% modified starch, and 23% water)		The flour could be kneaded, and dough sheets could be prepared.
2 (60% banana flour, 12% modified starch, and 28% water).		The flour could be kneaded, and dough sheets could be prepared.
8 (40% banana flour, 22% modified starch, and 38% water).		The flour could be kneaded; the texture of the dough was soft, and dough sheets could be prepared.
9 (40% banana flour, 27% modified starch, and 33% water).		The flour could be kneaded, and dough sheets could be prepared

Based on the findings from Table 4, flour from formula numbers 1, 2, 8, and 9 were selected to study their ability to form pasta dough accordingly.

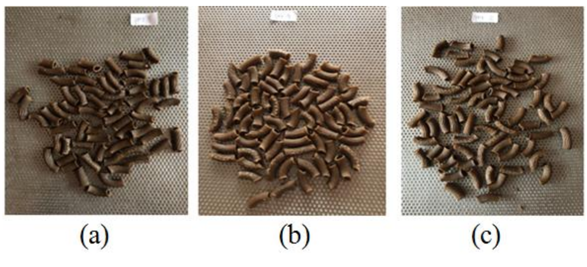

Figure 4. Pasta using formulae (a) number 1, (b) number 2, and (c) number 9

When all 4 flour formulae were used to produce pasta, it was found that formula numbers 1, 2, and 9 could be used to produce pasta noodles (as shown in Figure 4); however, recipe number 8 could not be used to produce pasta noodles as the flour seemed to be loose.

All 3 pasta flour formulae were tested for their sensory quality based on the preference of 60 consumers toward pasta, pasta in tomato sauce with minced chicken using the 9-point hedonic scale and measured cutting and shearing force. The observations have been presented in Table 5, Table 6, and Table 7.

Table 5. Mean values of the preference scores corresponding to different pasta characteristics

Characteristics	The mean of preference score		
	1	2	9
Appearance	$5.83^{c}\pm1.37$	$6.37^{b}\pm1.35$	$7.00^{a}\pm1.21$
Color	$5.92^{b}\pm1.43$	$6.08^{b}\pm1.37$	$6.67^{a}\pm1.27$
Overall aroma and taste	$5.33^{b}\pm1.80$	$5.58^{b}\pm1.68$	$6.23^{a}\pm1.60$
Elasticity	$5.42^{b}\pm1.53$	$5.42^{b}\pm1.57$	$6.32^{a}\pm1.81$
Softness and chewiness	$5.32^{b}\pm1.57$	$5.32^{b}\pm1.72$	$6.42^{a}\pm1.62$
Overall preference	$5.63^{b}\pm1.48$	$5.57^{b}\pm1.69$	$6.78^{a}\pm1.25$

Remark: ns means no statistical significance ($p>0.05$).
a, b, c refers to the mean scores in a vertical line with statistical significance ($p\leq0.05$).
± means standard deviation.

Table 5 shows that the mean values of the consumer preference scores corresponding to all 3 pasta formulae were significant ($p<0.05$). Formula number 9 exhibited the highest mean values of preference scores for appearance, color, overall aroma and taste, elasticity, softness and chewiness, and overall preference as it contained more modified starch than the other formulae. The modified starch has water absorption capacity and gelatinization property. When it turns into gel, it can firmly bind together other ingredients, which enhances the product's chewiness and elasticity [15]. Here, the banana flour ingredient has water absorption and low SP properties; however, at a higher temperature, it exhibits increased elasticity, which is similar to that of the modified starch [16].

Table 6. Mean values of consumer preference scores corresponding to different characteristics of pasta in tomato sauce with minced chicken

Characteristics	The mean of preference score		
	1	2	9
Appearance	$6.40^{b}\pm1.28$	$6.52^{b}\pm1.21$	$7.12^{a}\pm1.01$
Color	$6.30^{b}\pm1.22$	$6.55^{b}\pm1.18$	$6.95^{a}\pm1.18$
Overall aroma and taste	$5.93^{b}\pm1.45$	$6.10^{b}\pm1.51$	$6.73^{a}\pm1.30$
Elasticity	$5.58^{b}\pm1.73$	$5.72^{b}\pm1.46$	$6.52^{a}\pm1.75$
Softness and chewiness	$5.57^{b}\pm1.58$	$5.75^{b}\pm1.57$	$6.38^{a}\pm1.86$
Overall preference	$5.73^{b}\pm1.59$	$5.97^{b}\pm1.48$	$6.78^{a}\pm1.62$

Remark: ns means no statistical significance ($p>0.05$).
a, b, c refers to the mean scores in a vertical line informed by different letters with statistical significance ($p\leq0.05$).
± means standard deviation.

Table 6 indicates the significant differences in the mean values of consumer preference scores toward all 3 pasta product formulae ($p<0.05$). Formula number 9 had the highest mean values of preference scores corresponding to appearance, color, overall aroma and taste, elasticity, softness and chewiness, and overall preference.

Table 7. Physical properties of the obtained pasta products

Formula	Cutting force (N)	Shearing force (N)
1	$1.76^{b}\pm0.30$	$1.18^{b}\pm0.13$
2	$1.90^{b}\pm0.12$	$1.42^{b}\pm0.16$
9	$2.30^{a}\pm0.25$	$1.86^{a}\pm0.34$
Control	$2.32^{a}\pm0.18$	$2.06^{a}\pm0.24$

Remark: a, b refers to the mean scores in a vertical line informed by different letters with statistical significance ($p\leq0.05$).
± means standard deviation

Table 7 shows that the cutting and shearing force values of all 4 pasta product formulae were significant ($p<0.05$). The formula number 9 product had the highest cutting and shearing force values, which were not different from those of the commercial product (control). Higher cutting and shearing force will have an effect on the product texture, which will impart chewiness and elasticity to the products. These findings were consistent with the experimental results as recipe number 9 contained more modified starch than the other recipes; hence, the resulting pasta product exhibited enhanced elasticity, softness, and chewiness. Modified starch has water absorption capacity and gelatinization property. When it turns to gel, it can hold other ingredients and make all ingredients to hold firmly and harmoniously, enabling the product to gain more chewiness and elasticity [15]. Meanwhile, pasta had banana flour ingredient having water absorption and low swelling power properties but when banana flour receives a higher temperature, it will contain very high elasticity similar to modified starch [12].

Based on the experimental results, recipe number 9 was the most appropriate for producing gluten-free pasta using banana flour.

3.2. Quality Assessment of Gluten-free Pasta Made Using Banana Flour

3.2.1. Assessment of Physical, Chemical and Microbial Quality

Gluten-free pasta was produced using the banana flour according to formula number 9, and its physical quality, chemical quality, and microbial composition were analyzed. The results are shown in Table 8.

Based on the results obtained for physical quality assessment of the gluten-free pasta product made using banana flour in Table 8, it was revealed that the cutting force and shear force were 2.30 (N) and 1.86 (N), respectively. The cutting force and shear force determine elasticity as the pasta product had ingredients such as the modified starch and banana flour with water absorption capacity and gelatinization property. The water activity value (a_w) of the gluten-free pasta product made using banana flour was 0.52. This value (a_w) is an important factor for controlling and preventing food product deterioration, which directly impacts the shelf life of food products. A water activity (a_w) value less than 0.6 will help prevent bacteria, yeasts, and fungi from spoiling food products [17].

Table 8. Evaluation of the physical, chemical and microbial quality of the gluten-free pasta made using banana flour

Quality	Content	Unit (per 100-gram sample)
Physical quality		
Cutting force	2.30	N
Shear force	1.86	N
Water activity value (a_w)	0.52	Percentage
Chemical quality		
Moisture content	7.10	Percentage
Total energy	469.29	Kilocalories
Energy from fat	184.77	Kilocalories
Total fat	20.53	Grams
Saturated fat	4.31	Grams
Cholesterol	162.34	Milligrams
Protein	4.71	Grams
Carbohydrate	66.42	Grams
Dietary fiber	7.60	Grams
Total sugar	2.99	Grams
Sodium	38.55	Milligrams
Vitamin A (beta carotene)	26.69	Microgram
Vitamin B1	0.039	Milligrams
Vitamin B2	0.093	Milligrams
Calcium	60.30	Milligrams
Steel	1.33	Milligrams
Ash	1.24	Grams
Microbial quality		
Total microorganisms	1.63×10^2	cfu
Yeast	80	cfu
Coliform	< 3	MPN

The findings from the study on chemical quality (i.e., moisture content and nutritional profile of the gluten-free pasta product made using banana flour) showed that its moisture content was 7.10%, which is consistent with the Thai industrial standards of pre-cooked macaroni products (TIS number 1008-1990) that indicate that the moisture content of fully cooked macaroni products should not exceed 12% [18]. With respect to its nutritional profile, it was observed that 100 grams of the banana flour pasta product yielded 469.29 kilocalories of total energy; of which, 184.77 kilocalories of energy was derived from fats. Further, it included 20.53 grams of total fat, 4.31 grams of saturated fat, 162.34 milligrams of cholesterol, 4.71 grams of protein, 66.42 grams of carbohydrates, and 7.60 grams of dietary fiber that impart health benefits by improving the excretory system and trapping fat from foods; cellulose dietary fibers have water absorption property, contributing to softer stool, good excretion, no constipation problem, and no problems related to hemorrhoids, Hirschsprung's disease and colon cancer [19]. Moreover, 100 grams of the banana flour pasta product contained 2.99 grams of sugar, 38.55 milligrams of sodium, and 26.69 micrograms of Vitamin A. It is rich in Vitamin A and beta-carotene that are beneficial for the eyes because they stimulate the activation of the optic nerve system [20]. Moreover, 0.039 milligrams of Vitamin B1, 0.093 milligrams of Vitamin B2, 60.30 milligrams of calcium, 1.33 milligrams of iron, and 1.24 grams of ash were also observed. Further, the product was found to be rich in calcium and iron, which makes it suitable for elderly people and those with calcium deficiency. Calcium and iron strengthen bones and gums and improve the excretory system [21].

Evaluation of the microbial composition (i.e., total microorganisms, yeasts, fungi, and coliforms) in the gluten-free pasta product made using banana flour revealed that it meets the Thai industrial standards of pre-cooked macaroni products (TIS number 1008-1990) [18].

3.2.2. Evaluation of the Prebiotics Property of the Gluten-free Pasta Product Made Using Banana Flour

The growth of *L. plantarum* DSM 2648 and *E. coli* TISTR 8379 was monitored as shown in Figure 5 and Figure 6, respectively.

As shown in Figure 5, *L. plantarum* DSM 2648 cultured in the basal medium with the addition of the banana flour for pasta exhibited a higher cell count with significance (p<0.05) than those cultured in the basal medium exclusively. The oligosaccharides found in banana flour could help promote the growth of microorganisms that produce lactic acid, such as *L. plantarum* DSM 2648.

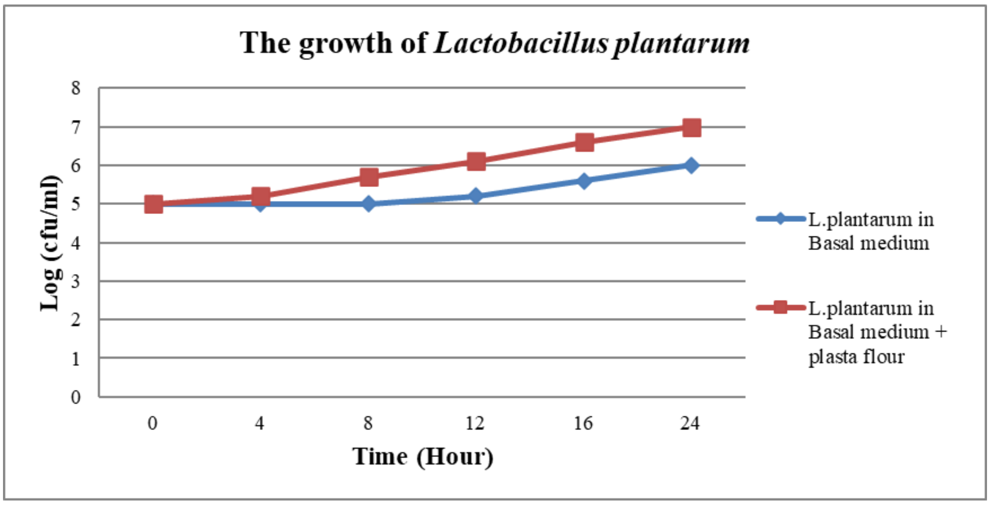

Figure 5. The growth curve of *Lactobacillus plantarum* DSM 2648 cultured in basal medium and basal medium + pasta flour

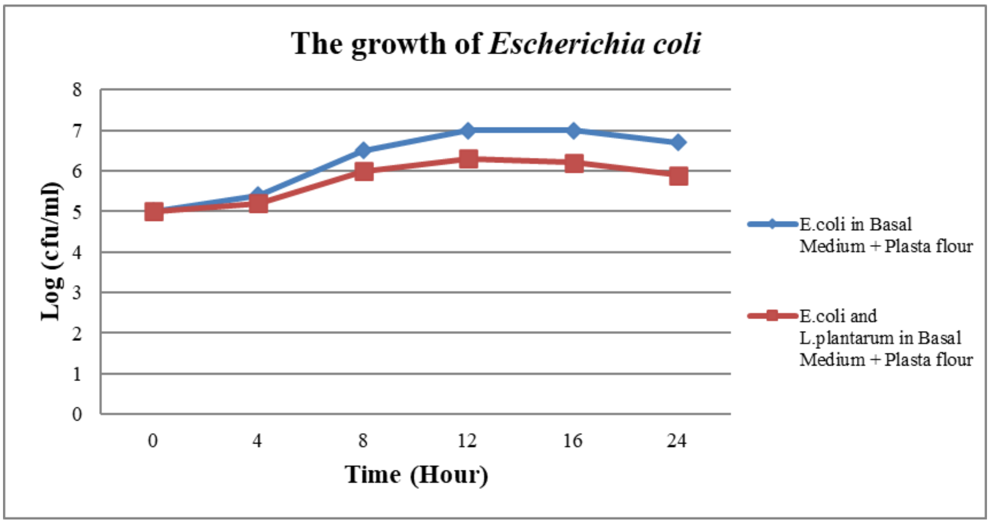

Figure 6. The growth curve of *Escherichia coli* TISTR 8379 cultured in basal medium + pasta flour.

Figure 6 shows that the growth of *E. coli* TISTR 8379 was inhibited by lactic acid-producing bacteria, that is, *L. plantarum* DSM 2648 when cultured in the media with the pasta flour made using banana. The oligosaccharides in the pasta flour made using banana promoted *L. plantarum* growth, which inhibited *E. coli* growth. According to Murry [22] revealed that *L. plantarum* could inhibit the growth of *E. coli* because microorganisms producing lactic acid could lower the pH of the media and reduce the growth of pathogenic bacteria; alternatively, the lactic acid-producing bacteria could also produce antibacterial agents such as organic acids, bacteriocins, and hydrogen peroxides. Our experimental results revealed that the pasta made using the banana flour had prebiotics properties.

3.3. Evaluation of the Sensory Quality

Pasta based on formula number 9 was produced and its sensory quality was tested based on the preferences of 100 consumers toward pasta in tomato sauce with minced chicken. Most of the consumers were women, who accounted for 67.0% of the consumers. Their income ranged from less than or equal to 15,000 baht, which accounted for 41.0%.

The results of the sensory evaluation of pasta in tomato sauce with minced chicken based on its appearance, color, overall flavor, elasticity, chewiness, and overall appeal are presented in Table 9.

Table 9. The mean values of preference scores towards characteristics of pasta in tomato sauce with minced chicken

Characteristics	The mean of preference score
Appearance	7.39 ±1.24
Color	7.06 ±1.41
Overall flavor	7.16 ±1.38
Elasticity	7.04 ±1.51
Chewiness	6.86 ±1.61
Overall appeal	7.02 ±1.26

Remark ± means standard deviation.

Based on the results, the highest mean value of the preference score with respect to the pasta in tomato sauce with minced chicken was observed for appearance; further, the results for color, overall flavor, elasticity, chewiness, and overall appeal attributes implied that the pasta was liked moderately. Moreover, 87.6 % of the consumers showed their interest in buying the gluten-free pasta made using banana flour because it was a healthy and nutritious food product.

4. Conclusion

The evaluation of banana flour quality revealed that it contains 5.43 grams of dietary fiber, 16.67% of calcium, and 1.22 milligrams of iron. Its swelling power at 85 ℃ was 78.82 gram/gram dry weight and its solubility at 85 ℃ was 13.65%.

The appropriate formula for pasta production is 40% banana flour, 27% modified starch, and 33% water.

Nutritional value of the gluten-free pasta product per 100 grams, 469.29 kilocalories of total energy, 4.71 grams of protein, 66.42 grams of carbohydrate, 7.60 grams of dietary fiber, 26.69 micrograms of Vitamin A, 0.039 milligrams of Vitamin B1, 0.093 milligrams of Vitamin B2, 60.30 milligrams of calcium, 1.33 milligrams of iron, and 1.24 grams of ash. Overall preference for consumption of the product is at a moderate level, and most consumers are interested in purchasing pasta products made from the banana flour.

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