บทความวิจัย

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สมบัติทางเคมีกายภาพและคุณภาพทางประสาทสัมผัสของพาสต้าปราศจากกลูเตนจากแป้งข้าวกล้องเสริมคุณค่าโปรตีนไข่ขาว

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บทคัดย่อ

ผลิตภัณฑ์ปราศจากกลูเตนได้รับความนิยมเพิ่มสูงขึ้นทั่วโลก งานวิจัยนี้มีวัตถุประสงค์เพื่อพัฒนาพาสต้าปราศจากกลูเตนจากแป้งข้าวกล้องเสริมคุณค่าโปรตีน และศึกษาสมบัติทางเคมีกายภาพและการยอมรับของผู้บริโภคต่อผลิตภัณฑ์ที่พัฒนาได้ โดยศึกษาปริมาณแป้งผสมระหว่างแป้งข้าวกล้อง (Brown Rice Flour; BRF) และแป้งพรีเจลาติไนซ์ (Pre-gelatinized Cassava Starch; PGCS) (BRF : PGCS 100 : 0, 95 : 5 และ 90 : 10) ไข่ขาวผง (EWP ที่ระดับ 5 และ10%) และแซนแทนกัม (XG ที่ระดับ 5 และ 10%) วางแผนการทดลองแบบ Full Factorial in CRD วิเคราะห์สมบัติทางเคมีกายภาพ ได้แก่ เวลาในการหุงต้ม การสูญเสียระหว่างการหุงต้ม การดูดซับน้ำ ความแข็งโดยการวัดด้วยเครื่องวิเคราะห์เนื้อสัมผัส และทดสอบทางประสาทสัมผัส โดยใช้ผู้ทดสอบชิม จำนวน 50 คน ด้วยการให้คะแนนแบบ 9-point Hedonic Scale ร่วมกับความสนใจซื้อ เฉพาะตัวอย่างที่มีการสูญเสียระหว่างหุงต้มน้อย เสิร์ฟตัวอย่างแบบ Sequential Monadic ครั้งละ 4 ตัวอย่าง และสุ่มเสิร์ฟแบบสมบูรณ์ จากผลการศึกษาพบว่า ที่ระดับไข่ขาวผงเดียวกัน เมื่อระดับของ PGCS และ XG เพิ่มขึ้น ส่งผลให้ตัวอย่างพาสต้าใช้เวลาในการหุงต้มมีการสูญเสียระหว่างหุงต้ม และการดูดซับน้ำเพิ่มขึ้น เมื่อทดสอบทางประสาทสัมผัส พบว่า ตัวอย่างที่มีส่วนผสมของ BRF : PGCS/EWP/XG ที่ระดับ 95 : 5/10/5 ได้รับคะแนนความชอบด้านลักษณะปรากฏ กลิ่น และเนื้อสัมผัส มากที่สุด ทั้งที่มี และไม่มีซอสพาสต้า ความสนใจในการซื้อของผู้บริโภคของตัวอย่างนี้สูงถึง 78% และหนึ่งหน่วยบริโภค 50 กรัม มีปริมาณโปรตีน 12.1% ซึ่งเทียบเคียงกับปริมาณโปรตีนของตัวอย่างพาสต้าทางการค้า

คำสำคัญ: ปราศจากกลูเตน, พาสต้า, ไฮโดรคอลลอยด์, โปรตีนไข่ขาว, คุณภาพการหุงต้ม

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Research Article

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Physicochemical Properties and Sensory Quality of Gluten-free Brown Rice Pasta Enriched with Egg White Protein

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Abstract

Gluten free (GF) products are increasingly interested worldwide. The objective of this research was to develop gluten-free pasta from brown rice flour enriched with egg white protein and to evaluate physicochemical quality and consumer acceptability of developed gluten-free brown rice pasta formulations. Composite flour from Brown Rice Flour (BRF) and Pre-gelatinized Cassava Starch (PGCS) (BRF : PGCS at 100 : 0, 95 : 5 and 90 : 10), egg white powder (EWP at 5 and 10%, w/w), and xanthan gum (XG at 5 and 10%, w/w) were applied using full factorial in CRD to produce gluten-free pasta. Developed pasta was subjected to physicochemical properties including cooking time, cooking loss, water absorption, and hardness using texture analyser. Sensory evaluation using 9-point hedonic scale (with and without pasta sauce) (n=50) for the selected GF pasta which had low cooking loss was conducted and served using sequential monadic for 4 samples of each set with counterbalanced serving. The results showed that at the same level of EWP, as the levels of PGCS and XG increased, cooking time, cooking loss and water absorption increased. The hardness of GF pasta decreased as the level of PGCS increased. Sensory quality showed that pasta containing BRF : PGCS/EWP/XG at the level of 95 : 5/10/5 gained the highest liking score in terms of appearance, aroma, texture as well as overall liking, both with and without pasta sauce. The purchase intention of the selected GF pasta was up to 78%. The protein content was 12.1% which was comparable to the protein content of the commercial wheat pasta based on a serving size of 50 g.

Keywords: Gluten-free, Pasta, Hydrocolloid, Egg White Protein, Cooking Quality

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1. Introduction

Pasta is one of the most popular carbohydrate based food product and consumed worldwide. It possesses unique nutritional as a low GI product which starch is slowly digested and absorbed in the small intestine [1]. However, it is still typically made from durum wheat flour containing gluten. Gluten gives negative impacts on human health, particularly in the coeliac disease patients who are intolerance to this protein fraction [2]. Currently, the only effective therapy is based on a life-long adherence to a gluten-free diet [2], [3].

Some cereals such as rice flour [4], corn flour [5], amaranth flour [6], and brown rice flour [7] are considered gluten free and known to be safe for the coeliacs. Therefore, the use of alternative cereal flours in pasta formulations could confer interesting characteristic and provid modifications in the nutritional quality of the various formulations [8]. Rice flour is widely used to prepare gluten free (GF) products according to its specific quality, including bland taste, high digestibility, and hypoallergenic properties [9], [10]. Additionally, brown rice is a better source of fiber and contains more nutrients than does white rice [11].

However, rice contains low protein and has relatively poor technological properties in interacting and developing a cohesive network. To produce GF pasta, the method obtained pre-gelatinized starch which was gone through heat and cool stages resulting in a rigid network based on the retrograded starch [4].

Protein, one of the most important factors affecting pasta properties, is commonly used as a structure building ingredient in solid and semi-solid foods to provide mechanical strength and characteristic textural properties of a product [12]. Egg protein has multifunctional properties such as gelling, foaming and emulsifying characteristics, in addition to their high nutritional quality. It was incorporated to improve firmness and elasticity as well as protein content of the developed pasta [6], [9], [13].

In addition, hydrocolloids [14], [15] were added to improve the quality of GF pasta through their ability to bind water. Hydrocolloids increase the rehydration rate of pasta during cooking or soaking [9]. Xanthan gum has been employed to the end product for several important reasons, including temperature stability, shear thinning rheological properties, and improvement of firmness and mouthfeel [9], [16]. The objectives of this research were, therefore, 1) to develop the gluten-free pasta from brown rice flour enriched with egg white protein and 2) to evaluate physicochemical quality and consumer acceptability of developed gluten-free brown rice pasta formulations.

2. Materials and Methods

2.1 Raw materials

Pasta was developed using following food-grade ingredients: wheat flour (White swan®, United Flour Mill Public Co., Ltd., Samut Prakarn, Thailand), brown rice (*Oryza sativa* sp.) (Tesco®, Bangkok, Thailand) ground into flour and passed through 100 mesh sieve, Pre-gelatinized Cassava Starch (PGCS) (Ingredion Co. Ltd., Bangkok, Thailand), salt (Prung Thip®, Pure Salt Industry Co., Ltd., Nakhonratchasima, Thailand), Xanthan Gum (XG) (Union Chemical 1986 Co., Ltd., Bangkok, Thailand), rice bran oil (King®, Thai Edible Oil Co., Ltd., Bangkok, Thailand) and Egg White Powder (EWP) (Thai Food and Chemical Co., Ltd., Bangkok, Thailand).

1.2 Pasta formulation and processing

The formulation was based on 100 g flour basis, consisting of brown rice flour (BRF) mixed with Pre-gelatinized cassava starch (PGCS) (BRF : PGCS at 100 : 0, 95 : 5 and 90 : 10), xanthan gum (XG: 5 and 10% w/w), egg white powder (EWP: 5 and 10% w/w) and the following ingredients: salt (2%), rice brand oil (19%) and water (70–90%). A mixture of ingredients and water was mixed by hand to form a rough dough. Then rice bran oil was added and knead to form a smooth dough. The dough was then rested and covered with plastic wrap for 30 min at room temperature (28±2°C). After that, the dough was sheeted and cut into 40 mm of length and 1.5 mm of thickness using a pasta maker. The pasta was then steam-cooked using a steamer for 10 min and dried in a tray dryer at 60 ± 5°C for 4 h to obtain less than 10% moisture content.

3. Cooking Quality of Pasta

3.1 Optimal cooking time

The optimal cooking time (OCT) was determined according to AACC method no. 66–50 [17]. Ten-gram of pasta was put into a pot containing 1,000 mL of boiling water with stirring and partially covering the pot to help reduce evaporation and maintain consistent temperature. After that, a piece of pasta was removed from cooking water at 30 sec intervals and squeezed it between two pieces of clear plastic. When the center core of pasta disappeared, the cooking time was recorded.

3.2 Cooking loss

The cooking loss of pasta was determined according to the AACC2000 method no. 66–50 [17]. Five-gram of pasta was cooked in 50 mL of boiling tap water (the ratio of pasta : water = 1 : 10). Pasta samples were cooked using the optimum cooking time. The cooking water was collected in an aluminum can, placed in an air oven at 105°C and evaporated until obtaining a constant weight. The residue was weighted and reported as a percentage of the starting material.

3.3 Water absorption

The cooked product was drained for 3 min and weighted to determine waster absorption as following equation;

Water absorption = [(weight of cooked pasta) – (weight of raw pasta)]/(weight of raw pasta)

3.4 Texture properties

The hardness of pasta (40 mm of length and 1.5 mm of thickness) was measured according to the method of [18] using a texture analyzer (Instron model 5966, Instron, Norwood, MA, USA) equipped with 1 kN load cell and a cutting plate. The test applied with a direct force to the sample using a constant crosshead speed of 5 mm/min. At least six measurements from two different sets of pasta were analyzed. The maximum load (N) of samples was recorded.

3.5 Sensory evaluation

The sensory evaluation was carried out by 50 untrained panelists (20–50 years of age;

equally divided among men and women) who had consumed pasta in the last 45 days and have no allergic to gluten and all ingredients used in the pasta formulations. The sensory attributes of the cooked gluten-free pasta were evaluated using a 9-point hedonic scale. Panelists were asked to evaluate sensory attributes including appearance (color and smoothness), flavor, texture and overall liking (with and without pasta sauce). The purchase intention was investigated based on 5-point likert scale.

The most acceptable formulation of GF pasta was selected and evaluated for the fat and total protein content (conversion factor of 5.95x%N) according to [19] method.

4. Statistical Analysis

All results were subjected to analysis of variance (ANOVA). The Duncan's Multiple Range Test (DMRT) was performed for post-hoc multiple comparison. Statistically significant difference was established at $P < 0.05$. Pearson correlation was employed between the textural quality from instrumental measurement and sensory evaluation.

5. Results and Discussions

5.1 Pasting profiles of native flour and composite flours

The viscosity behaviour of BRF (100%) and composite flours (BRF : PGCS at the ratios of 95 : 5 and 90 : 10 w/w) was shown in Table 1. The incorporation of PGCS significantly affected on the pasting profiles of the composite flours ($P < 0.05$).

As the levels of PGCS increased, peak, trough, final and breakdown viscosity decreased. This may be due to the reduction of the proportion of BRF in the dough and the loss of the crystallinity in PGCS which when reheat the viscosity might decrease [20]. The proportion of amylose content was also an important factor affecting those pasting profiles [21]. Additionally, Yousif *et al*. [22] also reported that pregelatinized starch resisted the breakdown of paste. Pregelatinization significantly modified pasting behaviour of composite flour. The viscosity profile indicated that the starch granules in PGCS were already swollen and highly susceptible to the hydration [4]. During the cooling phase, composite flour with PGCS exhibited less retrogradation intensity compared to BRF.

Table 1 Pasting properties of brown rice and composite flour measured using RVA

Sample (BRF : PGCS)	Peak Viscosity (RVU)	Trough (RVU)	Breakdown (RVU)	Final Viscosity (RVU)	Setback from Trough (RVU)
100 : 0	231.42 ± 4.41^{a}	131.83 ± 2.85^{a}	99.58 ± 5.17^{a}	291.69 ± 5.17^{a}	159.86 ± 3.96^{a}
95 : 5	164.53 ± 1.47^{b}	117.19 ± 0.63^{b}	47.33 ± 1.29^{b}	267.33 ± 1.04^{b}	150.14 ± 0.76^{b}
90 : 10	125.31 ± 0.90^{c}	98.97 ± 0.43^{c}	26.33 ± 0.60^{c}	237.50 ± 1.15^{c}	138.53 ± 0.72^{c}

$^{a–d}$ Means ± SD followed by difference letters the same in a column are significantly difference at $P < 0.05$.

BRF = Brown Rice Flour

PGCS = Pre-gelatinized Cassava Starch

5.2 Physicochemical quality of GF brown rice pasta

5.2.1 Moisture content

The moisture content of dried GF pasta was in the range of 4.7–6.2% (wet basis) complying with the standard of pasta of FDA [23]. The GF pasta containing the highest level of PGCS, EWP, and XG obtained the highest moisture content (6.2%) which may be due to the hydration capacity of all ingredients used in the formulations. All cooked GF pasta contained of 68.2–73.5% (wet basis) moisture content.

5.2.2 Cooking quality

The cooking quality of cooked GF pasta are summarized in Table 2. Cooking loss, an index of resistance to disintegration during cooking of pasta, is widely used as an indicator of the overall cooking performance of pasta [24]. According to the lack of a gluten network in GF pasta, starch molecules were less capability to form the matrix, resulting in a finished product with a high cooking loss. The increase of cooking loss observed in pasta with BRF was likely due to its higher fiber content responsible for a weakening of the starch network [7].

The EWP had less effect on the cooking loss of the GF pasta samples. Nonetheless, the addition of BRF : PGCS at the ratio of 95 : 5 and 5% XG was effectively improved the quality of GF pasta by forming a starchy network, thus lowering cooking loss and increasing water absorption [4]. The cooking loss was the highest value for GF pasta with BRF : PGCS of 90 : 10. This result agreed with the study of [25] who revealed that traditional pasta (from durum wheat) added with inulin and pea fiber had

Table 2 Cooking quality of different GF pasta formulations

Ingredient			Cooking Time (min)	Cooking Loss (%)	Water Absorption (%)
BRF : PGCS	EWP (%)	XG (%)			
100 : 0	5	5	10.3 ± 0.21^{b}	6.96 ± 0.03^{fg}	124.10 ± 7.08^{abc}
100 : 0	10	5	11.1 ± 0.15^{a}	6.66 ± 0.24^{g}	116.56 ± 9.10^{abc}
100 : 0	5	10	7.0 ± 0.21^{e}	8.74 ± 0.53^{def}	115.72 ± 29.03^{bc}
100 : 0	10	10	8.1 ± 0.20^{d}	8.99 ± 0.44^{de}	101.96 ± 0.34^{cd}
95 : 5	5	5	7.2 ± 0.10^{e}	7.86 ± 0.18^{efg}	82.93 ± 5.51^{d}
95 : 5	10	5	8.3 ± 0.25^{d}	8.56 ± 0.75^{defg}	113.63 ± 8.41^{bc}
95 : 5	5	10	8.1 ± 0.25^{d}	10.47 ± 0.61^{bcd}	125.36 ± 10.66^{abc}
95 : 5	10	10	9.0 ± 0.15^{c}	12.37 ± 2.56^{ab}	140.31 ± 2.94^{a}
90 : 10	5	5	8.0 ± 0.15^{d}	11.70 ± 0.76^{bc}	130.79 ± 6.70^{ab}
90 : 10	10	5	9.1 ± 0.20^{c}	13.92 ± 1.03^{a}	117.01 ± 0.67^{abc}
90 : 10	5	10	8.3 ± 0.20^{d}	11.48 ± 0.37^{bc}	126.15 ± 6.89^{ab}
90 : 10	10	10	9.1 ± 0.15^{c}	10.15 ± 1.58^{cd}	123.52 ± 23.20^{abc}

$^{a-g}$ Means± SD followed by difference letters in each column are significantly difference at $P < 0.05$.

higher cooking loss than that of the control. These might because of the losing out of solid. As the structure protein-starch was destroyed resulting in solid losing out. The lower amylose content might also have caused the weaker gel structure [22] affecting the cooking quality, especially in terms of textural properties.

Moreover, increasing amount of both BRF : PGCS (90 : 10) and XG (10%) up to the highest level resulted in higher cooking losses. It may contribute the formation of very sticky structure of mixed flour as a result of the lack of a well-structured protein reticule, hindering the excessive swelling of the starch granules and the consequent dispersion of components in the cooking water [26]. However, the cooking loss among GF pasta samples in the present study was in the range of 6–14% which was in accordance with the research of [27], who reported that the acceptable level of cooking loss for the semolina spaghetti was in the range of 7–8%.

The results also showed that GF pasta samples had significant differences in water absorption. In particular, the addition of PGCS and XG promoted the high hydrophilic starchy structure and resulted in high water absorption. As the PGCS and XG increased, the water absorption tended to increase.

The absorption among all GF pasta samples significantly increased ($P < 0.05$). However, an increase in water absorption of pasta depends on the size and shape of pasta [28] as well as the process of drying and cooking [29]. Sozer [9] also reported that hydrocolloids can increase viscosity and improve the texture of pasta with higher water absorption values.

5.2.3 Textural quality

The texture characteristics of raw, steamed, and cooked pasta samples were shown in Table 3. The hardness value of raw, steamed, and cooked pasta was in the range of 1–3 N, 2–14 N and 1–3 N, respectively. The steaming method promotes the gelatinization and protein denaturation resulted in newly organized starch structures that retard further starch swelling and solubilization during cooking [30]. Therefore, steamed GF pasta was stronger than that of the raw and cooked samples. While, the similar trend of hardness value for raw and cooked pasta was observed.

In addition, the obvious result was observed that the GF pasta was responsible for low values of hardness. When increasing the level of PGCS and XG, hardness values tended to increase compared to that of the control. However, when the high level of PGCS (BRF : PGCS of 90 : 10) was incorporated in the GF pasta formulation, the hardness of GF pasta significantly decreased compared to others. These may associate with a high cooking loss resulted from the reduction for the ability of a network structure formation between protein and starch.

Protein has received considerable attention as the most important factors affecting quality of GF pasta [30]. The good quality of pasta was reflected as good firmness and less stickiness. The steamed GF pasta containing BRF : PGCS/EWP/XG at the level of 95 : 5/10/10 showed the highest hardness values (14.6 N) than the others formulations. The modifications of protein-starch organization may be responsible for reducing stickiness and increasing hardness of the sample [7]. In addition, there are

Table 3 Effect of ingredients on the hardness GF pasta formulations

Ingredient			Hardness (N)		
BRF : PGCS	EWP (%)	XG (%)	Raw Pasta	Steamed Pasta	Cooked Pasta
100 : 0	5	5	2.31 ± 0.47[cd]	9.15 ± 1.35[cd]	3.33 ± 1.14[abc]
100 : 0	10	5	2.61 ± 0.36[bcd]	9.96 ± 1.39[c]	2.63 ± 0.33[cdefg]
100 : 0	5	10	2.52 ± 0.58[bdg]	2.01 ± 0.61[e]	2.55 ± 0.32[efg]
100 : 0	10	10	2.55 ± 0.23[cd]	6.51 ± 0.34[e]	2.25 ± 0.13[cfg]
95 : 5	5	5	3.25 ± 0.43[a]	6.43 ± 1.07[e]	2.68 ± 0.46[bdef]
95 : 5	10	5	2.87 ± 0.74[abcd]	11.83 ± 2.27[b]	3.49 ± 0.80[ac]
95 : 5	5	10	2.45 ± 0.20[de]	7.20 ± 0.98[de]	2.89 ± 0.70[abde]
95 : 5	10	10	3.17 ± 0.42[ab]	14.55 ± 2.38[a]	3.37 ± 0.62[ab]
90 : 10	5	5	3.12 ± 0.34[abc]	6.37 ± 1.10[e]	3.01 ± 0.26[abcd]
90 : 10	10	5	3.42 ± 0.43[a]	8.50 ± 1.11[cd]	2.99 ± 0.33[abcd]
90 : 10	5	10	3.31 ± 0.67[a]	8.76 ± 2.21[cd]	2.46 ± 0.15[defg]
90 : 10	10	10	1.91 ± 0.30[e]	8.71 ± 2.61[cd]	1.93 ± 0.50[g]

[a–g] Means±SD followed by difference letters in a column are significantly difference ($P < 0.05$).

various studies revealed that egg protein could form a more compact network resulted in higher firmness of pasta samples leading to a reduction in cooking loss as protein level increased [30] resulted in higher firmness of pasta samples. [12] also reported that GF pasta containing parboiled rice flour with egg albumen had significant lower cooking loss when compared with whey protein. However, differences observed in this study from others studies may be due to different structure and particle size of each ingredients as well as a ratio of water to composite flour in the pasta formulation which might cause the different matrix formation and starch gelatinization to form different stable structures.

5.2.4 Sensory quality

Selected formulations were used for sensory evaluation and the results were summarized in Table 4. The results showed that degree of liking scores among all pasta formulations were significantly different ($P < 0.05$). Increasing levels of XG, the results showed that the acceptability scores tended to decrease. Therefore, pasta with very sticky texture and high cooking loss corresponded to the formulation with the highest level of PGCS (BRF : PGCS = 90 : 10), thus it was not included in the sensory evaluation. The results indicated that the important attributes that most affect consumer acceptability were flavor and texture of the GF pasta formulations. The correlation also confirmed that the overall liking correlated with the sensory liking score in terms of flavour (r = 0.931), texture liking (r = 0.924) as well as hardness value from the instrumental measurement (r = 0.793), respectively (data not shown).

Table 4 Mean liking scores of different cooked GF pasta using 9-point hedonic scale (n = 50)

Ingredient			Appearance	Flavor	Texture	Overall Liking	
BRF : PGCS	EWP (%)	XG (%)				without Pasta Sauce	with Pasta Sauce
100 : 0	5	5	6.1 ± 1.3^{ab}	5.8 ± 1.2^{ab}	5.6 ± 1.7^{b}	5.8 ± 1.42^{b}	6.2 ± 1.36^{b}
100 : 0	10	5	5.6 ± 1.4^{bc}	5.6 ± 1.2^{ab}	5.4 ± 1.5^{b}	5.5 ± 1.5^{bc}	5.9 ± 1.36^{bc}
100 : 0	5	10	6.1 ± 1.3^{ab}	5.9 ± 1.3^{ab}	5.2 ± 1.8^{bc}	5.7 ± 1.6^{bc}	5.9 ± 1.38^{bc}
100 : 0	10	10	5.3 ± 1.3^{c}	5.5 ± 1.2^{b}	4.6 ± 1.6^{c}	5.1 ± 1.5^{c}	5.5 ± 1.51^{c}
95 : 5	5	5	5.8 ± 1.3^{bc}	5.7 ± 1.2^{ab}	5.6 ± 1.6^{b}	5.7 ± 1.2^{bc}	6.1 ± 1.18^{b}
95 : 5	10	5	6.6 ± 1.2^{a}	6.2 ± 1.3^{a}	6.4 ± 1.4^{a}	6.4 ± 1.3^{a}	6.7 ± 1.19^{a}
95 : 5	5	10	4.5 ± 1.6^{d}	5.7 ± 1.2^{ab}	4.9 ± 1.3^{bc}	5.6 ± 1.5^{bc}	6.3 ± 1.15^{ab}
95 : 5	10	10	5.5 ± 1.5^{c}	5.9 ± 1.1^{ab}	5.4 ± 1.5^{b}	5.7 ± 1.1^{bc}	6.2 ± 1.22^{b}

$^{a–d}$ Means ± SD followed by difference letters in a column are significantly difference ($P < 0.05$). GF pasta with BRF : PGCS of 90 : 10 was not selected to test for sensory evaluation according to high cooking loss and not acceptable texture (too sticky and too soft).

The GF pasta containing BRF : PGCS/EWP/XG at the level of 95 : 5/10/5 gained the highest scores for all sensory attributes including appearance, flavor, texture and overall acceptance (6.2–6.7; like slightly). This also noticeably affected the purchase intention of consumer which was up to 78%. Moreover, the liking of pasta was higher when conducting taste test of pasta with sauce. The formulation that obtained the lowest appearance and texture liking was the GF pasta formulation with BRF : PGCS/EWP/XG at the level of 95 : 5/5/10 which was likely due to higher cooking loss (10.47%) and lower hardness value (2.89 N) than others. Therefore, selected proximate analysis were performed for the most acceptable of GF pasta formulation. The fat and protein content of the selected GF pasta formulation was of 9.8% and 12.1%, respectively. The results indicated that the developed GF pasta obtained protein content comparable to the commercial pasta that contained protein content about 10–12%.

6. Conclusions

Based on the overall results, it could be concluded that the levels of PGCS, EWP and XG were significantly affected the physicochemical and sensorial quality of gluten-free brown rice pasta. The results indicated that as the levels of PGCS and XG increased, the cooking time, cooking loss and water absorption tended to increase, whereas, hardness was likely decreased. The EWP had small effect on those all qualities. Sensory evaluation indicated that the GF pasta formulated with BRF : PGCS/EWP/XG at the level of 95 : 5/10/5 gained the highest acceptability for all sensory attributes (like slightly) and purchase intention was up to 78%. The higher overall liking directly correlated with higher sensory score in terms of flavor and texture. The protein content of the developed GF pasta was of 12.1% comparable to the commercial pasta product and higher than the normal GF pasta. The preliminary consumer test showed that the developed GF pasta was as acceptable as commercial organic pasta (data not shown). Thus, results demonstrated that it is possible to develop gluten-free pasta from brown rice flour with good quality and comparable protein content to wheat pasta. The further challenge study was to ensure the product with higher consumer acceptability and to understand factors affecting consumer willingness-to-purchase of GF pasta enriched with protein content.

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