ผลของโปรตีนไข่ขาวผงต่อสมบัติทางเนื้อสัมผัส คุณภาพการหุงต้ม และการยอมรับทางประสาทสัมผัสของสปาเกตตีแป้งข้าวปราศจากกลูเทน

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บทคัดย่อ

วัตถุประสงค์ของงานวิจัยนี้เพื่อตรวจสอบผลของไข่ขาวผงต่อสมบัติทางด้านเนื้อสัมผัส คุณภาพการหุงต้ม และการยอมรับทางประสาทสัมผัสของสปาเกตตีแป้งข้าว ในการทดลองนี้ ใช้แป้งข้าวโม่แห้งผสมกับไข่ขาวผงในอัตราส่วน 5 ระดับ คือ ร้อยละ 0, 2.5, 5.0, 7.5 และ 10 ของน้ำหนักแห้ง ทำการขึ้นรูปให้เป็นเส้นสปาเกตตีด้วยเครื่องเอกทรูเดอร์ชนิดสกรูคู่ แล้วอบแห้งที่ 50 องศาเซลเซียส ทำให้ได้ผลิตภัณฑ์สปาเกตตีทุกตัวอย่างมีปริมาณกลูเทนน้อยกว่า 1 พีพีเอ็ม โดยการเติมไข่ขาวผงช่วยปรับปรุงคุณภาพการหุงต้มของสปาเกตตีด้วยอัตราส่วนไข่ขาวผงร้อยละ 5.0 ของน้ำหนัก เหมาะสมกว่าอัตราส่วนอื่น เนื่องจากช่วยลดเวลาในการคืนรูปลงจาก 17.6 นาที เป็น 15.2 นาที และค่าการสูญเสียระหว่างการหุงต้มลดลงจากร้อยละ 25.5 เป็น 18.9 ซึ่งดีกว่าเส้นสปาเกตตีที่ไม่เติมไข่ขาวผง ค่าความแน่นเนื้อเพิ่มขึ้นจาก 2.23 เป็น 2.38 นิวตัน ค่าแรงยึดเพิ่มขึ้นจาก 0.07 เป็น 0.12 นิวตัน นอกจากนี้ ผลการยอมรับทางประสาทสัมผัส โดยทดสอบความชอบด้วยวิธี hedonic-scale คะแนน 1 ถึง 9 ปรากฏว่า การใช้ไข่ขาวผงร้อยละ 2.5 ถึง 5.0 ได้รับคะแนนการยอมรับทางเนื้อสัมผัส (6.00-6.23) และความชอบโดยรวม (5.96-6.10) ดีกว่าอัตราส่วนอื่นในเกณฑ์ชอบเล็กน้อย ดังนั้นจึงสรุปได้ว่าการใช้ไข่ขาวผงร้อยละ 2.5 ถึง 5.0 สามารถปรับปรุงสมบัติทางเนื้อสัมผัส คุณภาพการหุงต้ม และได้รับการยอมรับทางประสาทสัมผัสดีกว่าตัวอย่างสปาเกตตีจากแป้งข้าวอื่น

คำสำคัญ : แป้งข้าว, โปรตีนไข่ขาวผง, สปาเกตตี

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EFFECT OF EGG WHITE PROTEIN POWDER ON THE TEXTURAL PROPERTIES, COOKING QUALITIES AND SENSORY EVALUATION OF GLUTEN-FREE RICE SPAGHETTI

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Abstract

The present study aimed to investigate the effect of egg white protein powder (EW) on textural properties, cooking qualities and sensory evaluation of gluten-free rice spaghetti (GFRS). Dry-milled rice flour was mixed with the different concentrations of EW 5 ratio; 0 %, 2.5 %, 5.0 %, 7.5 % and 10.0 %, dry basis. The spaghetti was processed using a co-rotating twin-screw extruder and then dried at 50 °C. All GFRS samples contained less than 1 ppm gluten. The addition of EW decreased GFRS cooking time and cooking loss. The GFRS formulation containing 5.0 % EW showed suitable formulas as it could decrease the cooking time from 17.6 to 15.2 min, cooking loss from 25.5 to 18.9 %, the higher firmness (2.38 N) and tensile strength (0.12 N) better than GFRS without EW (firmness, 2.23 N and tensile strength, 0.07 N). The sensory evaluation using a 9-point hedonic scale showed that the GFRS containing 2.5-5.0 % EW showed the highest texture score (6.00-6.23) and overall liking score (5.96 - 6.10) better than other GFRS samples, corresponding to a "like slightly" rating. The results concluded that 2.5 to 5% EW formulas for GFRS provide better texture properties, cooking qualities and sensory evaluation, than the other rice spaghetti samples.

Keywords : Rice flour, Egg white protein powder, Spaghetti

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Introduction

Spaghetti is a staple food in many countries. It is made from durum wheat (*Triticum durum* L.) semolina. Gluten is the main protein and important factor to the cooking qualities of wheat spaghetti. Since the gluten network entraps the starch granules to prevent the matter loss during cooking, resulting in low cooking loss, high firmness and low stickiness (Zweifel, Handschin, Escher, and Conde-Petit, 2003) Gluten-intolerant people or celiac disease patient need to eat food without gluten or gluten-free foods. A gluten-free food is defined as food that contains less than 20 ppm of gluten (U.S. Food and Drug Administration, 2014). However, the removing gluten from food product could reduce the quality of products (Gallagher, Gormley, and Arendt, 2004).

Egg white proteins are utilized in food products for gelling, foaming and emulsifying characteristics, texture modified, heat setting and binding properties. In addition, egg white protein is complete protein and will increase the nutrition quality to food products (Mine, 1995). Many researchers reported concern using egg white protein in gluten-free products. Kerdsrilek (2010) improved the quality of rice noodle by adding fresh egg white protein, the results showed that the added egg white at 30 % w/w could increase tensile strength of rice noodle. The protein network separated from starch gel of rice noodle was observed using SEM and CLSM (Kerdsrilek (2010). Schoenlechner, Drausinger, Ottenschlaeger, Jurackova, and Berghofer (2010) improved the cooking qualities of gluten free pasta using a combination of amaranth, quinoa, and buckwheat (40:40:60), with 6% of egg white powder and 1.2% of emulsifier.

Objectives

1. To analyze the gluten content in all rice spaghetti samples compare to commercial wheat spaghetti.
2. To investigate the effects of egg white protein powder (EW) on the textural properties, cooking qualities and sensory evaluation of rice spaghetti samples compare to commercial wheat spaghetti.

Materials and methods

Two dry-milled rice flours were prepared from Chai Nat 1 (CNT1); high amylose rice and Rice Division 6 (RD6); waxy rice by following method of Detchewa, Thongngam, and Naivikul (2012).

Production of gluten-free rice spaghetti

The blended dry-milled rice flour was fixed the ratio of CNT1 rice flour to RD6 rice flour at 90:10 (w/w) by following report from Detchewa, Thongngam, and Naivikul (2012). EW was added to the blended rice flour at different concentrations 0, 2.5, 5.0, 7.5 and 10 % w/w, db as represent GFRS-EW0, GFRS-EW2.5, GFRS-EW5.0, GFRS-EW7.5 and GFRS-EW10, respectively. Blended rice flour and EW was mixed for 1 hour using a cubic mixer (Unique Tools Company, Thailand) and then extruded using a co-rotating twin-screw extruder (Model EVO25 A120, Clextral®, France). The barrel temperatures were 40°C, 70 °C, 95 °C, 95 °C, 80 °C and 70 °C for the zone 1 to 6, respectively. The die was designed with six 1.5-mm-diameter circular holes. The extruded rice spaghetti was dried in a hot-air oven at 50 °C until the moisture content below 12 % (w/w).

Appearance of GFRS

Appearances (smoothness and uniformity) of dried and cooked GFRS were observed using a stereomicroscope (x 10) (Leica, S8APO, Germany).

Scanning electron microscope

The surface of the dried spaghetti was determined using a scanning electron microscope (SEM). The samples were coated with gold and observed using a JEOL JSM-5300 LV SEM, USA. Micrographs of each spaghetti were determined at 1,000 x magnification.

Analysis of gluten content

The gluten content of rice spaghetti and commercial wheat spaghetti was determined using a monoclonal R5-antibody-based sandwich enzyme-linked immunosorbent assay (ELISA), wheat/gluten (gliadin) ELISA Kit II (Morinage Institute of Biological Inc., Japan). Assays were performed following standard procedures provided with the kit.

Cooking properties of spaghetti samples

The cooking qualities were determined using optimum cooking time and cooking loss following AACC method 66-50.01 (AACC, 2010). The disappearance of the central core as determined by squeezing the spaghetti between two glass plates will be optimum cooking time. Cooking loss was evaluated by measuring the amount of solids lost into the cooking water. The water absorption index based on the percent water absorbed was determined as the percent water absorbed weight gain after cooking.

Texture analysis of spaghetti

The textural properties of the spaghetti products were determined using a texture analyzer (TA-XT Plus, Stable Micro System, Godalming, England). The firmness of the spaghetti was measured following the AACC method 66-50.01 (AACC, 2010). Five strands of cooked spaghetti were placed in sample holder and cut crosswise using a 1 mm flat Perspex knife blade (A/LKB-F). Tensile strength was measured using a spaghetti/noodle tensile rig (A/SPR). A single strand of each noodle sample was locked in a slotted arm and measured at a test speed of 3.0 mm/s. and the maximum breaking force (N) was recorded. Stickiness was determined by the maximum force during lifting of the cylindrical probe (35 mm) from five cooked spaghetti (Wang, Bhirud, Sosulski, and Tyler, 1999).

Statistical analysis

All experiments were carried out in duplicate. The mean and standard deviation of the parameters were calculated, and the differences between the formulations were evaluated by analysis of variance (ANOVA), using the SPSS 17.0 statistical software program, and Duncan Multiple Range Tests (DMRT) to test the significant differences between treatments. Statistical significance was declared at $p<0.05$.

Sensory evaluation

The sensory characteristics of rice spaghetti and commercial wheat spaghetti were evaluated by 30 panelists. The panelists evaluated the randomly-coded pasta samples for their color, appearance, flavor, texture and overall acceptability. Sensory attributes were measured using a 9-point hedonic scale where 9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much and 1 = dislike extremely.

Results and discussion

Production of gluten-free rice spaghetti

The dried and cooked GFRS-EW0, GFRS-EW2.5 and GFRS-EW 5.0 showed smooth surface. GFRS-EW7.5 and GFRS-EW10.0 showed uneven and rough surface of dried samples, but cooked GFRS-EW7.5 and GFRS-EW10.0 were smooth surface. Whereas, the dried and cooked of commercial wheat spaghetti GFRS samples showed smooth surfaces and consistence shape (Figure 1).

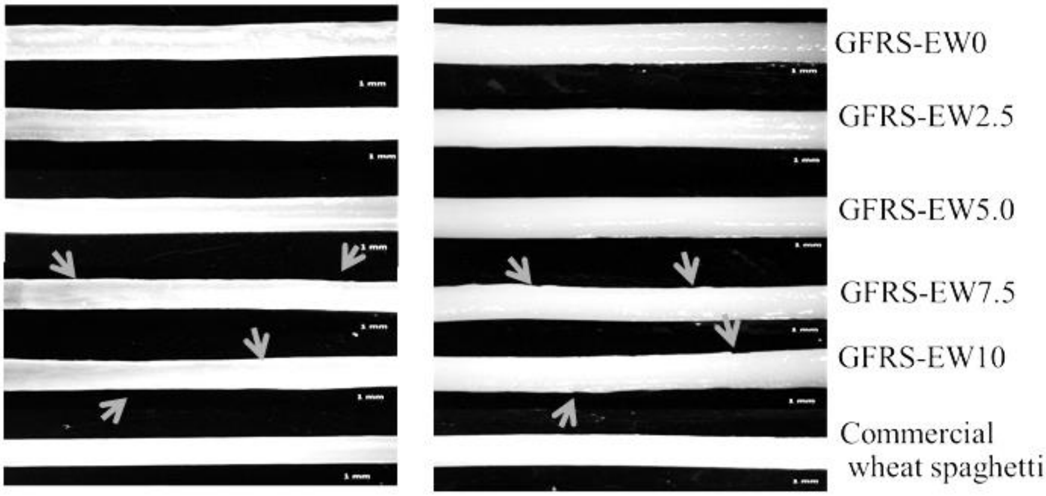

Figure 1 Dried and cooked GFRS with/without EW and commercial wheat spaghetti

The surface of dried GFRS with or without EW (Figure 2 A-E) showed no porous due to starch gelatinized during high temperature extrusion. This rice spaghetti samples were contained no gluten, thus gelatinized starch was necessary to form the strand. While, the surfaces of dried GFRS containing EW at 2.5 to 10.0% showed the smooth and shrink as film-like structure of EW. The surface of commercial wheat spaghetti showed some cracks and starch granules, which showed small and large granules (Figure 2F).

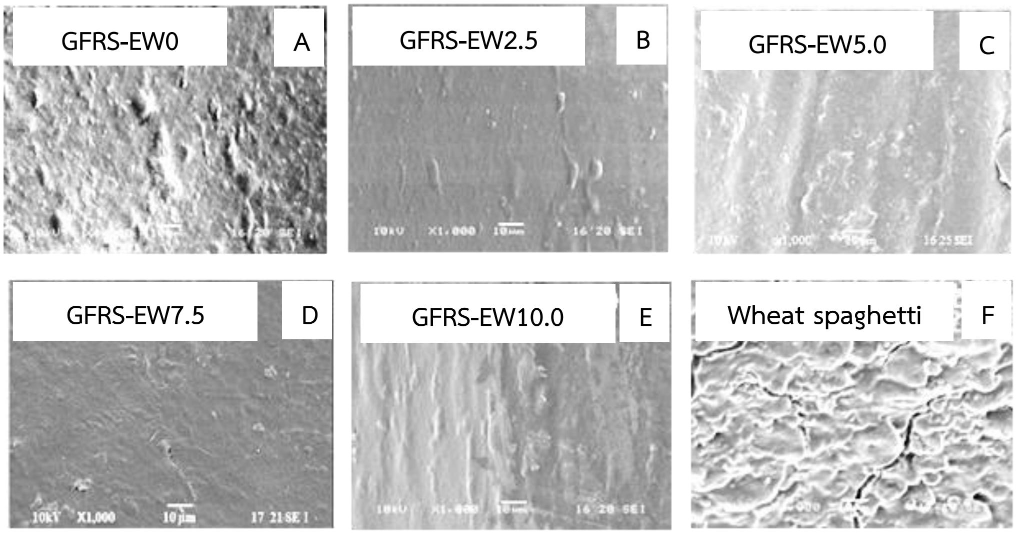

Figure 2 Scanning electron micrographs of dried surface of GFRS-EW0 (A), GFRS-EW2.5 (B),. GFRS-EW5.0 (C), GFRS-EW7.5. (D) GFRS-EW10.0 (E) and commercial wheat spaghetti (F).

Analysis of gluten content

The gluten content of rice spaghetti containing EW at 0, 2.5, 5, 7.5 and 10% were less than 1 ppm. Thus, each rice spaghetti was gluten-free food due to containing gluten less than 20 ppm (U.S. Food and Drug Administration, 2014). In contrast to the commercial wheat spaghetti, which was contained 167,630 ppm of gluten. Gluten is the main protein in wheat protein and responsible to structure and texture of wheat spaghetti (Shewry, Halford, Belton, and Tatham, 2002; Wieser, 2007).

The qualities of spaghetti samples

The qualities of spaghetti samples were determined by cooking time, cooking loss and water absorption index (Table 1). The optimum cooking time of GFRS-EW0 (17.6 min) had the longest time. It may be due to water was difficult to diffuse into the inner of strand. Adding EW to rice spaghetti from 2.5 to 10% resulted to decrease cooking time from 17.6 to 15.0 min. The commercial wheat spaghetti gave the shortest cooking time (12.2 min). It may be from the small pores and some cracks of commercial wheat spaghetti (Figure 2F). Thus, the water can easy penetrate to the commercial wheat spaghetti. The cooking loss of GFRS-EW0, GFRS-EW5.0, GFRS-EW7.5 and GFRS-EW10 were 19.3, 18.9, 23.9 and 25.6%, respectively. The differences in cooking loss depended on the strength of gel network of rice noodle (Bhattacharya, Zee, and Corke, 1999). The addition of EW to rice spaghetti at 2.5 or 5.0% could enhance the strength of starch gel network, while adding EW higher than 7.5% showed the higher cooking loss, it may be caused by a weakening of gel network strength. The commercial wheat spaghetti had the lowest of cooking loss (6.8%) due to protein network of the commercial wheat spaghetti can entrapping the starch and other constituents (Zweifel, Handschin, Escher, and Conde-Petit, 2003). The water absorption index of GFRS-EW0, GFRS-EW5.0, GFRS-EW7.5 and GFRS-EW10 were 246.4, 239.5, 234.6, 231.1 and 226.5 %, respectively. The water absorption index of commercial spaghetti was the highest value (298.5%). The adding EW to rice spaghetti resulted to decrease water absorption index of GFRS. It may be because of the EW, which was coated the outer of GFRS as shown in Figure 2.

Table 1 Cooking qualities of GFRS samples compare to commercial wheat spaghetti

Samples	Cooking time (min)	Cooking loss (%)	Water absorption index (%)
GFRS-EW0	17.6 ±0.7a	25.5±0.8a	246.4±4.2b
GFRS-EW2.5	15.3±0.1b	19.3±0.2c	239.5±2.1c
GFRS-EW5.0	15.2±0.2b	18.9±0.7c	234.6±1.1cd
GFRS-EW7.5	15.0±0.1b	23.9±0.5b	231.1±1.4de
GFRS-EW10.0	15.0±0.6b	25.6±0.6a	226.5±2.1e
Commercial wheat spaghetti	12.2±0.2c	6.8±0.4d	298.5±2.1a

Values are means of measurements ± standard deviation. Mean for each characteristic followed by the different letters within the same column are significantly different ($p<0.05$)

The texture properties of GFRS samples compared to commercial wheat spaghetti and were measured using a texture analyzer (Table 2). The firmness of GFRS-EW0, GFRS-EW2.5, GFRS-EW5.0, GFRS-EW7.5 and GFRS-EW10 were 2.23, 2.25, 2.38, 1.95 and 1.83 N, respectively. The tensile strength of GFRS-EW0, GFRS-EW2.5, GFRS-EW5.0, GFRS-EW7.5 and GFRS-EW10 were 0.07, 0.11, 0.12, 0.07 and 0.06 N, respectively. The stickiness of GFRS-EW0, GFRS-EW2.5, GFRS-EW5.0, GFRS-EW7.5 and GFRS-EW10 were 0.40, 0.24, 0.25, 0.35, and 0.77 N, respectively. The using EW to rice spaghetti at 5% in GFRS improved the firmness, tensile strength and stickiness. The commercial wheat spaghetti had the highest firmness (3.85 N), and tensile strength (0.30 N) but the lowest stickiness (0.10 N).

Table 2 Texture properties of GFRS samples compare to commercial wheat spaghetti

Samples	Firmness (N)	Tensile strength (N)	Stickiness (N)
GFRS-EW0	2.23±0.05c	0.07±0.01c	0.40±0.02b
GFRS-EW2.5	2.25±0.06c	0.11±0.01b	0.24±0.01c
GFRS-EW5.0	2.38±0.14b	0.12±0.01b	0.25±0.02c
GFRS-EW7.5	1.95±0.01d	0.07±0.01c	0.35±0.10b
GFRS-EW10.0	1.83±0.38d	0.06±0.01c	0.77±0.07a
Commercial wheat spaghetti	3.85±0.07a	0.30±0.01a	0.10±0.01d

Values are means of measurements ± standard deviation. Mean for each characteristics followed by the different letter within the same column are significantly different ($p<0.05$)

The sensory evaluation of spaghetti (1-9 hedonic scale) was shown in Table 3. GFRS-EW0 showed the appearance (6.10), texture (5.56), flavor (5.43), color (5.36) and overall liking (5.26) within the range of dislike slightly to like slightly. Whereas rice spaghetti contained EW at 2.5 and 5.0% showed appearance (6.40 – 6.03), texture (6-6.23), flavor (6.03-6.00), color (5.86-6.16) and overall liking (5.96-6.10) were in the range of like slightly. Moreover, GFRS-EW7.5 and GFRS-EW10.0 showed somewhat overall liking (5.43 -5.26), which referred to neither like nor dislike, however, the commercial wheat spaghetti showed the highest scores for all sensory attributes. further research are needed to improve the physical properties of rice spaghetti such as color and texture by adding other proteins, hydrocolloids or combination of proteins and hydrocolloids to optimize the GFRS formulation and to achieve good rice spaghetti characteristics.

Table 3 Effect of EW on the sensory evaluation of GFRS samples compare to commercial wheat spaghetti

Samples	Appearance	Texture	Flavor	Color	Overall liking
GFRS-EW0	6.10±0.69b	5.56±0.30cd	5.43±0.50bc	5.36±0.85c	5.26±0.28c
GFRS-EW2.5	6.40±1.52b	6.00±0.64bc	6.03±0.92b	5.86±0.56bc	5.96±0.60bc
GFRS-EW5.0	6.03±0.77b	6.23±0.21b	6.00±0.24b	6.16±0.35b	6.10±0.27b
GFRS-EW7.5	5.93±1.68b	5.46±0.93d	5.66±1.62bc	6.01±1.34bc	5.43±1.52bc
GFRS-EW10	6.40±1.70b	4.96±1.62d	5.26±1.83c	5.96±1.51bc	5.26±1.04c
Commercial wheat spaghetti	8.00±0.69a	7.60±0.72a	7.50±0.57a	8.06±0.64a	7.46±0.68a

Values are means of measurements ± standard deviation. Mean for each characteristic followed by the different letters within the same column are significantly different ($p<0.05$).

Conclusion

Rice spaghetti made from blending dry-milled rice flour and EW using a twin-screw extruder. The sample GFRS-EW2.5 and GFRS-EW5.0 were improved the surface of dried and cooked GFRS, which were observed under stereomicroscope. All rice spaghetti samples were gluten-free rice spaghetti (GFRS) due to contain gluten less than 1 ppm. The addition of EW to rice spaghetti significantly improved the textural properties, cooking qualities and sensory evaluation of rice spaghetti. The textural of GFRS was found that the GFRS-EW5.0 sample gave the highest firmness. The sensory evaluation showed that GFRS contained EW at 2.5 and 5 % was considered the optimum formula in the range of slightly like.

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