Journal of Current Science and Technology, May-August 2021 Vol. 11 No. 2, pp. 230-239

ISSN 2630-0656 Online)

Cite this article: Rungsardthong, V., Namprakob, P., Korkerd, S, & Lamsal, B. (2021, May). Physical and cooking properties of extruded rice spaghetti supplemented with mango peel fibre. *Journal of Current Science and Technology, 11*(2), 230-239. DOI: 10.14456/jcst.2021.24

Journal of Current Science and Technology
Journal homepage: https://jcst.rsu.ac.th

Physical and cooking properties of extruded rice spaghetti supplemented with mango peel fibre

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Received 9 February 2021; Revised 23 March 2021; Accepted 28 April 2021;
Published online 27 May 2021

Abstract

Mango peel is a rich source of dietary fibre and exhibits strong antioxidant capacity. Rice spaghetti was extruded from rice flour, defatted soy protein (10% w/w), and modified starch (3% w/w) and supplemented with dietary fibre from mango peel (MPF). The extruder was operated with the screw speed and feeder speed both at 30 rpm and a 1.6 mm diameter die. The barrel temperatures of zones 1, 2 and 3 was set at 60, 70 and 80 °C, respectively. The mixture was supplemented with MPF at 0%, 2.5%, 5.0%, 7.5% and 10.0% (w/w) of rice flour, which increased the total dietary fibre (8.13% to 21.01%) and the antioxidant capacity. The addition of more MPF resulted in rice spaghetti with a darker colour. Substitution of MPF up to 5.0% (w/w) produced pasta strands with good cooking stability. Overall liking scores for the product containing 2.5% MPF (w/w) were not significantly different from those for the control (without MPF). The cooking time, cooking weight, cooking loss, and tensile strength of the rice spaghetti containing 2.5% MPF (w/w) were 11.00 min, 235.81%, and 7.74%, respectively. Moreover, the products with 5.0–10.0% MPF could be claimed as fibre-enriched gluten-free products. The results show the potential for supplementing gluten-free rice spaghetti during extrusion with mango peel for dietary fibre and antioxidant activity.

Keywords: *antioxidant capacity; cooking quality; dietary fibre; extrusion; mango peel; rice spaghetti.*

1. Introduction

The consumption of pasta has increased due to its ease of preparation, handling, transportation, and cooking (Tudorica, Kuri, & Brennan, 2002). Generally, pasta is made from durum wheat flour in which gluten is the most significant factor that affects the cooking quality (Sozer, 2009). While pasta firmness increases and stickiness decreases with the increase in protein or gluten content, gluten-free pasta for people with celiac disease could not have that benefit (Bouasla, Wójtowicz, & Zidoune, 2017). Several studies have examined various aspects of using gluten-free raw materials other than durum wheat flour. Rice flour can be used to produce gluten-free pasta; even though it has a bland taste and high digestibility, rice pasta can have characteristics similar to those of semolina pasta (Phongthai, D'Amico, Schoenlechner, Homthawornchoo, & Rawdkuen, 2017). Direct extrusion can be applied to produce rice pasta with a high production output and very low wastage (Charutigon, Jitpupakdree, Namsree, & Rungsardthong, 2008; Sereewat et al., 2015) compared to slower conventional rice noodle production process, which is energy-intensive with higher losses (Fu, 2008). However, the lack of gluten leads to rice pasta with softer texture (Sozer, 2009). Using appropriate substitute ingredients, such as modified starch, emulsifiers, and protein can overcome the absence of gluten to improve pasta structure and texture (Padalino, Conte, & Del Nobile, 2016; Rungsardthong et al., 2021).

Recent trend in consumer health concerns has led to more nutritionally rich food products. Many studies on the development of pasta enriched with various ingredients to improve the functional and nutritional aspects have been reported (Mercier, Moresoli, Mondor, Villeneuve, & Marcos, 2016). Defatted soy flour, the by-product from oil extraction, has been used to increase the protein content in rice spaghetti (Sereewat et al., 2015) and also in expanded snacks (Korkerd, Wanlapa, Puttanlek, Uttapap, & Rungsardthong, 2016). Defatted soy flour and durian peel powder supplementation was used to produce dietary fibre-enriched rice spaghetti by extrusion (Srirachan et al., 2021). The pasta exhibit acceptable physical properties, including appearance, noodle stability after cooking, and sensory acceptability, compared to commercial products made from durum semolina.

Thailand is well known for the cultivation, processing, and export of tropical fruits such as mango, durian, and pineapple. Peels from fruits such as apple, mango, and pear contain fibre at more than 30% of dry weight (Grigelmo-Miguel, Carreras-Boladeras, & Martín, 1999). Kaeo mango is the mango variety popularly used as raw material for giving some products. Kaeo mango peel has a well-balanced soluble and insoluble dietary fibre fractions commonly classified into two fractions: insoluble, including cellulose, hemicellulose and lignin which stimulate an increase in faecal bulk; and soluble, including pectins, β-glucans and galactomannan which can help lower blood cholesterol and regulate blood glucose levels (Rodŕiquez, Jiménez, Fernández-Bolaños, Guillén, & Heredia, 2006; Tungland & Meyer, 2002). Kaeo mango peel dietary fibres exhibit desirable properties such as high total polyphenol and flavonoid content, and high antioxidant capacity (Pierson et al., 2015; Wanlapa, Wachirasiri, Sithisam-ang, & Suwannatup, 2015). The phenolic content in mango peel is much higher than that found in red grape seeds (14.3-22.28 mg GAE/100 g; Negro, Tommasi, & Miceli, 2003; Wanlapa et al., 2015). In addition, these fruit by-products still contain a lot of nutrients which are beneficial to health and can be added into rice pasta. In addition, mango is one of the seven fruits which account for the largest volume of peel in Thai fruit processing plants. The potential use of these mango peel not only adds value to the food products but also helps keep the environment clean.

2. Objectives

The overall objective of this research was to develop nutritious gluten-free pasta from rice flour supplemented with food processing by-products. This research aimed 1) to produce gluten-free rice spaghetti from rice flour partially substituted with mango peel fibre, defatted soy flour, and modified starch, 2) to study the physical and cooking properties of the extruded rice spaghetti partially substituted with mango peel fibre, and 3) to carry out a sensory evaluation of the cooked rice spaghetti thus obtained.

3. Materials and methods

3.1 Materials and chemicals

Defatted soy flour (DSF) was supplied by Thai Vegetable Oil PCL, the size which was reduced using a Hammer Mill (Retsch, Germany) and further sieved through a 70 Mesh sieve (210 µm). The samples were dried to less than 9% moisture content using a hot air oven at 55 °C. The dried samples were milled with a 0.5 mm mesh screen, packed, and sealed in polyethylene bags and kept at room temperature until use. Fresh Kaeo mango peel was supplied by Samroiyod Co., Ltd. (Prachuap Khirikhan Province, Thailand), a company which produces dried tropical fruits for export. The peels were washed and blanched in hot water at 90 °C for 10 min and dried in a hot air oven at 60°C. The dried mango peel fibre (MPF) with moisture content 8.5% (wwb) was milled using an 80-100 mesh pin mill and sealed in a zip-log plastic bag. Rice (*Oryza sativa* L.) flour (RF, particle size 2-8 µm) with an amylose content of 26-30% was purchased from Bangkok Inter Food Co., Ltd. Ester-modified starch (MS) from cassava starch, Perfectamill A.C. (particle size 10-25 µm), was obtained from National Starch and Chemical (Thailand) Co., Ltd. RF was white in colour while DSF and MPF were yellow and yellow-brown as shown in Figure 1.

3.2 Chemical composition and analysis of raw materials

The protein and lipid content of RF, DSF, MS, and MPF were analysed following AOAC methods 12.1.07 and 920.39C (2000). The ash and moisture content were determined with AACC methods 8-01 and 44-19 (2000). The amylose content of RF was measured following Juliano (1971) as described by Charutigon et al. (2008). Briefly, the sample (0.1 g) was added with 1 mL of 95% ethanol and 9 mL of 1 N NaOH, shaken and boiled for 5-10 min. The sample was diluted after cooling and left at room temperature for 18 h. Glacial acetic acid and iodine solution were mixed with the sample and their absorbance was measured at 620 nm. A calibration curve was prepared using pure amylose from potato (Sigma) as the standard. Enzymatic and gravimetric methods were used to measure the total dietary fibre (TDF), soluble dietary fibre (SDF), and insoluble dietary fibre (IDF) of MPF following AOAC (2000) and Prosky, Asp, Schweizer, Devries, and Furda (1988) using a Megazyme analysis kit. The sample was hydrolysed with heat-stable α-amylase, protease, and amyloglucosidase in order to remove the protein and starch in the MPF. Ethanol (95%) was added to precipitate the SDF. The IDF was calculated as TDF − SDF. All analyses were performed in triplicate and expressed as the mean value.

The total phenolic compounds (TPC) of MPF were determined using the Folin–Ciocalteu method (Singleton, Orthoter, & Lamuela-Raventes, 1999) with some modification. The TPC concentration in the sample was expressed as mg of gallic acid equivalents (GAE) per 1 g of sample. The antioxidant activity of the methanol extract of the samples was determined by free radical scavenging activity by using 2,2-diphenyl-1-picrylhydrazyl (DPPH) following the method of Brand-Williams, Curvelier, and Berset (1995). The percentage of free radical scavenging activity was plotted against the amount of sample and the half-inhibition concentration (IC_{50}) was determined.

Rice flour Defatted soy flour Mango peel fibre

Figure 1 Raw materials used in the extrusion

3.3 Extrusion conditions and substitution of RF with MPF

Rice spaghetti was prepared using a single screw extruder (Brabender-19/20 DN) with a barrel length (L) = 20 D, barrel bore (D) = 19.1 mm and a 4: 1 screw compression ratio, as described by Sereewat et al. (2015). The barrel temperature of extruder zones 1, 2 and 3 (die) was set at 60, 80 and 100 °C, respectively; screw and feeder speeds were both at 30 rpm, and the die diameter was 1.6 mm. Each temperature zone was heated electrically and cooled by water and air cooling. The optimum RF:DSF:MS ratio of 87:10:3 by weight was selected from our previous study (Srirachan et al., 2021). Rice spaghetti was extruded with RF substituted with MPF at 2.5%, 5.0%, 7.5% and 10.0% (w/w) and dried to 11-12% moisture content at room temperature (27-31 °C) for about 24 h and kept in sealed polyethylene bags until further analysis. The appearance (smoothness, air bubbles, uniformity) of dried noodles was examined visually. The colour and cooking quality of the products were determined, and sensory evaluation was carried out (below). All analyses were carried out in triplicate and expressed as the mean value.

3.4 Colour

The extrudate colour was measured in terms of the CIE Lab system (Mahawar, Jalgaonkar, Nambi, Bibwe, & Thirupathi, 2018), where L* is lightness on a 0 to 100 scale from black to white; a* indicates (+) red or (−) green; and b* indicates (+) yellow or (−) blue, using a Hunter Lab spectrophotometer (Color Quest XE, Hunter Lab, Inc. USA). Five samples were used and data were averaged.

3.5 Cooking quality

Spaghetti cooking quality including cooking time and cooking loss was determined following AACC (2000). For cooking time, 5 g of 5 cm-long rice spaghetti was boiled in 300 ml of distilled water. Samples were taken every 10 s and pressed between two glass slides. The optimum cooking time was the time taken for rice spaghetti to be fully cooked when the hard core of the sample disappeared during the pressing. For cooking weight, the spaghetti boiled in 300 mL of distilled water with the optimal cooking time was weighed after removing excess water. Cooking loss was determined by evaporating the boil water used in the cooking weight process, at 105 ± 1 °C, in a hot air oven and calculated as follows:

Cooking weight (CW) = (weight of cooked pasta (g)/weight of sample before cooking (g)) × 100 (1)

Cooking loss (CL) = (weight of total solid in evaporation beaker (g)/weight of sample (g)) × 100 (2)

3.6 Sensory evaluation

Sensory evaluation was carried out using a 5-point hedonic test as detailed previously by Sereewat et al. (2015). Each category was rated from 1 (dislike very much) to 5 (like very much). Rice spaghetti containing different %MPF was cooked for the optimal cooking time and served as warm products to 40 untrained panellists who were students (female and male, 19-23 years old) at the Department of Agro-Industrial, Food, and Environmental Technology, King Mongkut's University of Technology North Bangkok. The products were evaluated in terms of colour, texture, cohesiveness, pasta stability (ease to split apart or not), and overall liking.

3.7 Statistical analyses

The experiment design was completely randomized with three replicates and three measurements each of pertinent parameters. The data were statistically analysed using analysis of variance (ANOVA). Duncan's new multiple range test ($p \leq 0.05$) was used to determine significant difference. A paired sample t-test was used to analyse the comparison of sensory tests, using SPSS version 18.0 for Windows.

4. Results and discussion

4.1 Chemical composition of raw materials

The moisture, fat, ash, and protein content of RF was 9.92%, 0.65%, 0.36% and 7.01% (wwb) respectively, as shown in Table 1. The amylose content of RF was 28.98% which is in the optimum range (higher than 25%) for producing rice pasta with acceptable texture or firmness (Jeong et al., 2016; Srirachan et al., 2021). The protein content of DSF and MPF was 46.74% and 4.13% (wwb), respectively. Soy protein is highly nutritious, high in protein, inexpensive, and widely used in many food products such as meat, dairy, and cereal products, snack food, and rice spaghetti (Sereewat et al., 2015; Jalgaonkar, Jha, & Mahawar, 2018; Srirachan et al., 2021). The TDF of MPF was 51.21% which included SDF at 22.12% and IDF at 29.09%. The TPC of MPF was 68.38 mg GAE/g sample with an IC_{50} of 0.06 ± 0.01 mg of sample. In comparison, the TDF of durian peel powder was reported as 73.12% with an IC_{50} of 2.82 mg, respectively (Srirachan et al., 2021), which means more active/effective in scavenging free radicals (antioxidant activity). The IC50 was much smaller for MPF which means MPF was more active or effective in scavenging free radicals than durian peel powder.

Mango peel has been reported as a good source of bioactive compounds including polyphenols, carotenoids and dietary fibre and has been added to pasta to increase its nutraceutical properties (Ajila, M., Leelavathi, & Rao, 2008). Dietary fibre and phenolic compounds have health-promoting benefits such as antioxidant, anticarcinogenic, and antimutagenic properties (Rein et al., 2013). Wanlapa et al. (2015) also reported the potential of selected tropical fruit peels as source of dietary fibre in functional foods. Dietary fibre from Kaeo mango peel presents a composition that is health-beneficial with moderate ability to hold water and oil (Wanlapa et al., 2015).

4.2 Physical properties and cooking quality of rice spaghetti

The rice spaghetti without MPF showed a light yellow colour due to the DSF added. Increasing MPF substitution from 2.5% to 10.0% (w/w) resulted in extruded rice spaghetti with a pale brown to dark brown colour, compared to the yellow colour of the control (without MPF). The pasta surface was slightly rough and split apart after boiling when MPF was increased to 7.5% and 10.0% (w/w). The dietary fibre in MFP may have interrupted formation of gel in the rice spaghetti, resulting in a less cohesive pasta strand (Majzoobi, Ostovan, & Farahnaky, 2011). The colour values of the extruded rice spaghetti with different degrees of MPF substitution are shown in Table 2. MPF had a yellow-brown colour compared to the white colour of RF as shown in Figure 1. Higher MPF substitution led to decreased brightness (L* value) and changes in other color components (a*, b*, and c*). The non-enzymatic Maillard browning reaction might occur during extrusion under right conditions. The Maillard browning is a complicated reaction involving amino compounds and reducing sugars at higher temperatures, leading to the formation of many heterocyclic, aliphatic compounds, and high molecular weight red or brown compounds like melanoidin pigments (Cui, Duhoranimana, Karangwa, Jia, & Zhang, 2018; Martins & van Boekel, 2003).

Table 1 Chemical composition of raw materials used for the extrusion of rice spaghetti

Component (%)	Rice flour	Defatted soy flour	Modified starch	MPF
Moisture	9.92 ± 0.13^{b}	7.86 ± 0.45^{a}	15.31 ± 0.20^{c}	8.35 ± 0.55^{ab}
Protein	7.01 ± 0.05^{c}	46.74 ± 0.30^{d}	0.04 ± 0.00^{a}	4.13 ± 0.11^{b}
Lipid	0.65 ± 0.01^{b}	1.16 ± 0.25^{c}	0.07 ± 0.00^{a}	2.01 ± 0.12^{d}
Ash	0.36 ± 0.03^{a}	6.63 ± 0.05^{c}	0.27 ± 0.02^{a}	2.89 ± 0.17^{b}
MPF				
Total dietary fibre	51.21 ± 1.08	Total phenolics (mg GAE/g sample)		68.38 ± 0.25
Soluble dietary fibre	22.12 ± 0.11	Free radical scavenging activity		
Insoluble dietary fibre	29.09 ± 0.22	IC_{50} (mg sample)		0.06 ± 0.01

Values are means ± SD of triplicate samples (n = 3)
Different superscript letters in the same row indicate significant difference ($p < 0.05$)

Table 2 Colour values of extruded rice spaghetti supplemented with mango peel fibre

MPF (% w/w)	L*	a*	b*	c*	h*
0	46.32 ± 10.09^{b}	6.28 ± 0.15^{a}	13.88 ± 0.71^{c}	54.49 ± 1.18^{a}	−4.60 ± 0.05^{a}
2.5	37.58 ± 1.03^{a}	6.61 ± 0.11^{b}	13.62 ± 0.58^{bc}	61.77 ± 1.11^{b}	−4.58 ± 0.04^{a}
5.0	37.43 ± 1.00^{a}	7.13 ± 0.25^{c}	12.69 ± 0.99^{b}	61.76 ± 0.84^{b}	−4.42 ± 0.09^{b}
7.5	37.57 ± 0.74^{a}	7.66 ± 0.18^{d}	11.53 ± 0.33^{a}	61.58 ± 0.91^{b}	−4.24 ± 0.04^{c}
10.0	37.13 ± 1.57^{a}	7.67 ± 0.29^{d}	11.66 ± 0.84^{a}	61.90 ± 1.30^{b}	−4.18 ± 0.11^{c}

Values are means ± SD of triplicate samples (n = 3)
Different superscript letters in the same column indicate significant difference ($p < 0.05$)

Table 3 shows that the cooking times for all products were in the range of 11.00-11.50 min. An increase in %MPF did not significantly affect the cooking time or cooking weight of the cooked rice spaghetti. Similar ranges for both cooking time and cooking weight have been observed for rice spaghetti supplemented with durian peel powder (Srirachan et al., 2021). The cooking loss of all treatments ranged 7.74-10.27%, which is still in the acceptable range for the commercial noodles (< 12.5% wet weight; Yeh & Jaw, 1999). Lower addition of MPF, for example at 2.5 and 5.0%, could reduce the cooking loss of the rice spaghetti. However, an increasing trend for the cooking loss was observed when MPF content was increased to 5.0 and 10.0%. Similar trend was observed with the supplementation of durian peel powder (DPP) to rice spaghetti by Srirachan et al. (2021), with lesser cooking loss at 2.5% substitution, that increased with the higher % DPP (5 to 10%). Lower amount of MPF in the gluten free rice spaghetti might lead to better protein starch interaction and gel matrix compared to the control (without MPF addition). Similar research indicates that incorporation of mango peel powder from 0 to 7.5% in durum wheat semolina increased the cooking loss in pasta from 5.84 to 8.71% (Ajila et al., 2010). Jalgaonkar et al. (2018) also reported higher cooking loss from 8.11 to 9.91% when mango peel powder was incorporated at 5 to 15% in wheat semolina-pearl millet pasta. The competitive hydration tendency of fibre can cause uneven distribution of water within the protein-starch matrix (Ajila, Aalami, Leelavathi, & Prasada Rao, 2010). Fibre in mango peel powder could impact the formation/development of the gluten network and may even lead to disruption of protein-starch matrix, (Ajila et al., 2010), higher cooking loss and decreased cohesiveness.

4.3 TDF and IC_{50}

TDF in the rice spaghetti ranged between 10.80-21.01% with different levels of MPF substitution (Table 4). Higher levels of TDF led to a lower IC_{50}, which consequently resulted in higher effectiveness in scavenging free radicals of the product. The addition of durian peel powder in rice pasta was reported to exhibit a similar trend (Srirachan et al., 2021). However, the extrusion of RF blended with MPF in this study significantly increased the antioxidant capacity of the extruded products as exhibited by their IC_{50} value. The temperature during extrusion may impact dietary fibre, protein profile, vitamins, and other nutrients both positively or negatively (Singh, Gamlath, & Wakeling, 2007). For example, IDF became more soluble after the extrusion of orange pulps (Larrea, Chang, & Martínez Bustos, 2005) and the TPC and total antioxidant capacity of extrudate containing cauliflower by-product increased (Stojceska, Ainsworth, Plunkett, & Ibanoglu, 2008).

Table 3 Cooking properties of rice spaghetti supplemented with mango peel fibre

MPF (% w/w)	Cooking time ^{ns} (min)	Cooking weight ^{ns} (%)	Cooking loss (%)
0	11.00 ± 0.00	223.71 ± 1.41	10.27 ± 2.21^{c}
2.5	11.00 ± 0.00	235.82 ± 6.69	7.74 ± 0.61^{a}
5.0	11.00 ± 0.00	240.67 ± 11.20	7.92 ± 0.44^{a}
7.5	11.50 ± 0.00	230.92 ± 10.51	8.39 ± 0.63^{ab}
10.0	11.50 ± 0.00	229.65 ± 11.75	8.53 ± 0.57^{b}

Values are means ± SD of triplicate samples (n = 3)
Different superscript letters in the same column indicate significant difference ($p \leq 0.05$)
ns: not significantly different

The Thai recommended daily intake of dietary fiber (RDI) was calculated as described by the Ministry of Public Health (2004). One serving size for uncooked rice spaghetti is 55 g and the Thai RDI for dietary fibre is 25 g. According to Thai food regulations, pasta containing from 20% TDF up to the Thai RDI can be claimed as 'high' or 'rich in dietary fibre' while a product can be claimed as a 'good source, contains, provides dietary fibre' if it has 10% to 19% of the Thai RDI (pl cite). Consequently, the rice spaghetti prepared in this study without MPF could be claimed as a 'source of fibre' (17.88% Thai RDI), while the extruded product with 2.5% MPF substitution could be claimed as 'rich in dietary fibre' (23.76%). Since the substitution of MPF resulted in increase in fibre content by more than 10% of the Thai RDI compared to the control, the products with 5.0-10.0% MPF could be labelled as 'fibre-enriched rice spaghetti' (29.10-46.22% Thai RDI).

4.4 Sensory evaluation

Table 5 summarizes the results of the sensory evaluation of extruded rice pasta carried out by 40 untrained panellists using a 5-point hedonic scale test. The addition of MPF at 2.5–10.0% (w/w) seemed not to affect the hardness of any product compared to the control. However, the panellists scored less for cohesiveness for all MPF addition levels. The addition of MPF at 5.0–10.0% (w/w) gave the products a brown colour, resulting in lower scores for the colour attribute. In conclusion, the overall liking scores obtained for the product with 2.5% MPF (w/w) were not significantly different to those for the rice spaghetti without MPF supplementation.

Table 4 Total dietary fibre and IC_{50} (determined by free radical scavenging activity using DPPH (of rice spaghetti with different MPF levels

MPF (% w/w)	Total dietary fibre (%)	Thai RDI (%)	IC_{50} (mg pasta)
0.0	8.13 ± 0.28^{a}	17.88	344
2.5	10.80 ± 0.20^{b}	23.76	24.21
5.0	13.23 ± 0.22^{c}	29.10	9.04
7.5	16.86 ± 1.41^{d}	37.09	4.17
10.0	21.01 ± 0.05^{e}	46.22	1.31

Values are means ± SD of triplicate samples (n =3)
Different superscript letters in the same column indicate significant difference ($p \leq 0.05$)

Table 5 Sensory evaluation of cooked rice spaghetti extruded from rice flour supplemented with mango peel fibre

MPF (% w/w)	Colour	Texture ^{ns}	Cohesiveness	Pasta stability	Overall liking
0	3.45 ± 0.68^{b}	3.60 ± 1.23	3.65 ± 1.04^{b}	3.50 ± 0.88^{b}	3.85 ± 1.13^{b}
2.5	3.31 ± 0.85^{b}	3.47 ± 090	2.94 ± 0.77^{a}	2.61 ± 0.84^{a}	3.15 ± 0.95^{ab}
5.0	3.32 ± 0.82^{b}	3.43 ± 0.90	3.00 ± 0.81^{a}	2.61 ± 0.69^{a}	3.00 ± 0.94^{a}
7.5	3.11 ± 0.96^{a}	3.42 ± 1.17	2.93 ± 0.08^{a}	3.33 ± 0.90^{b}	2.61 ± 0.97^{a}
10.0	3.05 ± 0.80^{a}	3.39 ± 1.05	2.95 ± 0.08^{a}	2.88 ± 0.67^{a}	2.77 ± 0.80^{a}

Values are means ± SD of triplicate samples (n = 3)
Different superscript letters in the same column indicate significant difference ($p \leq 0.05$)
ns: not significantly different

5. Conclusion

Gluten-free rice spaghetti was extruded from rice flour blended with defatted soy protein and MPF by direct extrusion. The composition analysis showed that MPF was high in TDF at 51.21%, including SDF at 22.12% and IDF at 29.09%. The MPF also exhibited a high content of TDF at 68.38 mg GAE/g sample, and high antioxidant capacity with an IC_{50} of 0.06 mg of sample. The RF in the blend was substituted with MPF at 0%, 2.5%, 5.0%, 7.5% and 10.0% (w/w) which increased TDF from 8.13% to 21.01% and lowered IC_{50} from 344 to 1.31 mg of sample. Increasing %MPF resulted in a product with a browner colour. The cooking time of all products was in the range 11.00-11.50 min. Increasing MPF did not significantly affect the cooking time or cooking weight of the cooked rice spaghetti, but lower cooking loss was observed. Overall liking scores for the product containing 2.5% MPF (w/w) were not significantly different to those for the rice spaghetti without MPF substitution. The extruded products with MPF substitution at 2.5% and 5.0-10.0% could be claimed as 'rich in dietary fibre', and 'fibre-enriched rice spaghetti', respectively. The results indicate a high potential to produce rice spaghetti from gluten-free RF supplemented with nutritional sources from defatted soy protein and MPF by a continuous and efficient extrusion process.

6. Acknowledgements

The authors would like to express their sincere appreciation to the National Research Council of Thailand through the NRCT Senior Research Scholar Program (Contract No.814-2020) and the Thailand Science Research and Innovation Fund, and King Mongkut's University of Technology North Bangkok (Contract no. KMUTNB-BasicR-64-29-3) for their financial support.

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