International Journal of Agricultural Technology 2020 Vol. 16(2): 329-338
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

The usage of rice bran flour and pea protein in pork patties and pork meatballs

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Peetitungwong, S., Chonmanawat, M., Santiwattana, P., Sirisukpornchai, T., Kaewsaad, T. and Theprugsa, P. (2020). The Usage of Rice Bran Flour and Pea Protein in Pork Patties and Pork Meatballs. International Journal of Agricultural Technology 16(2): 329-338.

Abstract Result found that the higher amount of extenders leading to higher the cooking yield, moisture retention and fat retention. Whereas, the diameter reduction and juiciness were decreased. The texture evaluation factors of all treatments were higher than the control treatment ($p<0.05$). For the color parameters, increased in pea protein caused the lightness, redness, yellowness, and protein content of the product to rise. The increase of rice bran flour caused fiber, ash, and carbohydrate to rise, but the lightness reduces. In addition, using rice bran flour and pea protein can reduce fat content. Sensory evaluation suggested that using rice bran flour and pea protein at 5% w/w in pork patties and pork meatballs had an overall acceptability similarly to the control. In conclusion, at 5% w/w or below each, rice bran flour and pea protein were suitable as extenders for pork patties and pork meatballs.

Keywords: Patties, Meatballs, Rice bran flour, Pea protein

Introduction

Minced pork and pork back fat are important constituents of pork patties and pork meatballs. They have high production costs and low dietary fiber. Consuming large amounts could have a negative effect on consumer health. The American Heart Association and other health organizations have recommended that consumers should reduce total dietary fat intake to lower their serum cholesterol concentrations (AHA, 1986).

Rice bran is a good dietary fiber source. Functional properties of rice bran have high oil or water absorption (Chandi and Sogi, 2007 and Hu and Yu, 2015). Rice bran has also been added to meat products. It can be seen that, addition 10% of rice bran to meatballs is similar to the controls (Huang *et al*., 2005). Low-fat meat batters with 10% vegetable oil and rice bran fiber had superior characteristics to the regular fat control (Choi *et al*., 2009). Choi *et al*.

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(2010) also reported that low-fat frankfurters with vegetable oil and rice bran fiber had sensory properties similar to the high-fat control.

Pea protein is a rich sources of lysine. It has been used in meat emulsions, beverages and bakery products. Pea protein is known to be stable in emulsion systems (Reinkensmeier *et al*., 2015; Osen *et al*., 2014; Sosulski and McCurdy, 1987). Many studies have been used pea protein adding in meat products. Vaisey *et al*. (1975) added field pea protein to beef patties, which showed similar firmness as the controls. Frankfurters with added pea protein showed no significant cooking loss compared with the control one (Tömösközi *et al*., 2001). Pietrasik and Janz (2010) found that the addition of pea starch and fibre fractions was similar to the high-fat bologna. However, no research has been use pea protein in the pork patties and pork meatballs.

The objective of this research was to study whether replacing meat and back fat with rice bran flour or pea protein in pork patties and pork meatballs produced physical, chemical and sensory effected that were consumers acceptant. Moreover, this study investigated the quality of rice bran oil after the frying of meatballs.

Materials and Methods

The basic formula of pork patties and pork meatballs were pork round, pork back fat, salt (PrungThip, Thai Refinrd Salt Co., Ltd., Thailand), pepper (Raitip, Thai Cereals World Co., Ltd., Thailand), onion and sugar (MitrPhol, MitrPhol group, Thailand), which were purchased from a local supermarket. Sodium tripolyphosphate (STPP) was purchased from Food Equipment Co., Ltd., Thailand. Rice bran flour, pea protein and rice bran oil were obtained from Thai Edible Oil Co., Ltd. Rice bran flour is a light brown powder of 60 mesh and Pea protein is a bright yellow powder of 48-50 mesh.

The basic formulations of pork patties and pork meatballs are given in the Table 1. Lean and fat were ground in a 5 mm plate grinder and frozen at -18 ℃ until reducing a final internal temperature of 0 ℃. All ingredients were mixed for 3 min. Then, the mixtures were the molded into pork patties and pork meatballs. The pork patties had an approximate weight of 70 g (9 cm diameter and 1.2 cm thickness) by using a round shaped mold and the pork meatballs had an approximate weight of 15 g (3-3.5 cm diameter) after ball forming. Lastly, all samples were packaged in plastic polyethylene bags and stored at -18 ℃ until further use.

The patties and meatballs were thawed in a cold room (4 ℃) for 2 h. The pork patties were cooked on a Teflon-coated frying pan without oil by flipping every 3 min until the final internal temperature of 75-78 ℃ was reached. The pork meatballs were deep fried in rice bran oil at 160 ℃ for 3 min and reach an internal end-point temperature of 75-78 ℃. After cooking, the samples were cooled to room temperature.

Table 1. Formulations of pork patties and pork meatballs (%)

Ingredients	Treatments				
	Control	T1	T2	T3	T4
Pork round	65	59.15	53.3	59.15	53.3
Pork back fat	20	18.2	16.4	18.2	16.4
Salt	1	0.91	0.82	0.91	0.82
Pepper	1.3	1.18	1.07	1.18	1.07
Ice	10	9.1	8.2	9.1	8.2
STPP	0.2	0.18	0.16	0.18	0.16
Minced onion	1	0.91	0.82	0.91	0.82
Sugar	1.5	1.37	1.23	1.37	1.23
Water	-	4	8	4	8
Rice bran flour	-	5	10	-	-
Pea protein	-	-	-	5	10

Treatments: Control = Not added rice bran or pea protein, T1 = 5% Rice bran flour, T2 = 10% Rice bran flour, T3 = 5% Pea protein, T4 = 10% Pea protein.

Cooking loss was determined according to the following by Ulu (2006):

$$\text{Cooking yield (\%)} = \frac{\text{cooked weight}}{\text{raw weight}} \times 100$$

Diameter reduction measurement was done by following Jeong *et al*. (2007) with some modifications. The changes in the diameter of the samples was determined by using the following equation:

$$\text{Diameter reduction (\%)} = \frac{\text{raw diameter - cooked diameter}}{\text{raw diameter}} \times 100$$

Juiciness was measured by using a press method following Gujral *et al*. (2002) and Serdaroğlu (2006) with some modifications. A sample (1.5×1.5×1.5 cm, 1 g) was placed between a pair of pre-weighed Whatman (No. 1) filter paper sheets covered with aluminium foil and pressed for 1 min at 25 kg force for patties and 10 kg force for meatballs. The residue was removed and the filter paper was weighed to determine the percentage of extracted juice, as follows:

$$\text{Juiciness (\%)} = (\text{weight of filter paper after pressing - weight of filter paper before pressing/ weight of sample}) \times 100$$

Moisture retention was determined by using an equation by El-Magoli *et al*. (1996):

$$\text{Moisture retention (\%)} = \frac{\text{\% yield} \times \text{\% moisture in cooked sample}}{100}$$

Fat retention was determined using an equation by Khalil (2000):

$$\text{Fat retention (\%)} = \text{\% yield} \times \frac{\text{\% fat in cooked sample}}{\text{\% fat in raw sample}}$$

The color (L*, a*, and b*) of the surface of samples was measured using a Hunter Lab digital colorimeter (Model Color Flex, Hunter Associates Laboratory, Reston, VA).

TPA measurement was done by following Gao *et al*. (2014) with some modifications. The samples were cut to a size of $2.75 \times 2.75 \times 1.00$ cm, and both cooked surfaces of the samples were removed. TPA of pork patties and pork meatballs was conducted by using a texture analyzer with a P50 probe (TA-XT PLUS, Lloyd Instruments, Hampshire, UK). Samples were placed on the center of the TPA plate and compressed to 70% of their original height at a constant test speed of 1 mm/min (pre test speed and post test speed were 5 mm/min and the testing interval was 5 s). Texture properties; hardness, springiness, cohesiveness, gumminess and chewiness were analyzed.

Sensory evaluation in terms of color, flavor, taste, tenderness, juiciness, and overall acceptability was using a 9-point hedonic scale test (9 = extremely desirable, 1= extremely undesirable). Fifty untrained panelists took part in the test. After that, water and sandwich bread was served for cleaning the mouth between samples. Moisture, protein, fat, fiber, ash, and carbohydrate contents were determined by the AOAC standard method (AOAC, 1997). The peroxide value was determined from the cooking oil used in frying pork meatballs (AOAC, 1997).

Experiments were done in triplicate. A completely randomized design (CRD) was used for all experiments, except sensory evaluation part which was performed in a randomized complete block design (RCBD). Data were analyzed by Analysis of Variance (ANOVA). Duncan's New Multiple Range Test was used to determine the differences between means at the 5% level ($p<0.05$).

Results

The effect of addition rice bran flour and pea protein on the cooking properties of pork patties and pork meatballs are shown in Fig. 1a and b. The addition of rice bran flour and pea protein increased cooking yield, moisture retention and fat retention and reduced the diameter and juiciness. Cooking yield, diameter reduction and juiciness were influenced by moisture and fat retention.

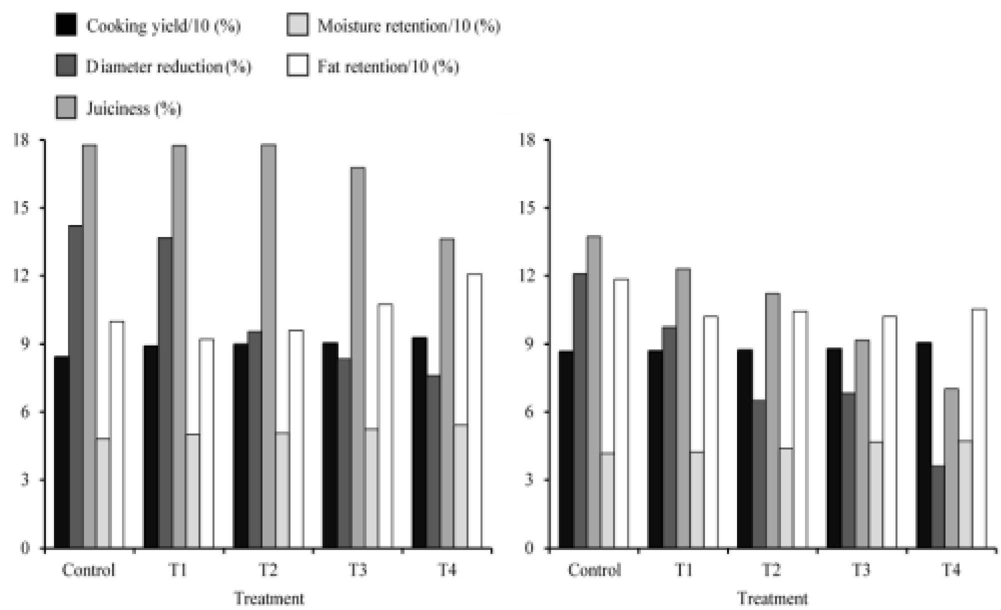

Figure 1. Cooking properties of cooked pork patties (a) and pork meatballs (b) varied with the addition of rice bran flour and pea protein: Treatments Control = Not added rice bran or pea protein, T1 = 5% Rice bran flour, T2 = 10% Rice bran flour, T3 = 5% Pea protein, T4 = 10% Pea protein

The texture profile analysis of the samples is given in Table 2 and 3. Increasing the proportion of rice bran flour and pea protein had a significant effect ($p<0.05$) on the textural properties of the pork patties and pork meatballs. Hardness, springiness, cohesiveness, gumminess and chewiness increased as the amount of rice bran flour and pea protein increased. Pea protein at 10% showed the highest texture evaluation factors.

The results for chemical composition are presented in Tables 2 and 3. The moisture content of the pork patties fluctuated as the level of rice bran flour and pea protein was increased, though the variation was not significant ($p>0.05$) but the moisture content of the pork meatballs increased significantly ($p<0.05$). The rice bran flour and the pea protein reduced the fat content below that of the control sample in both the pork patties and pork meatballs. The protein content was higher than control ($p<0.05$) with increased pea protein. The rice bran increased the fiber, ash and carbohydrate content.

Table 2. Color, texture profile analysis, proximate composition and sensory attributes of cooked pork patties varied with the addition of rice bran flour and pea protein

Parameters	Treatments				
	Control	T1	T2	T3	T4
Color					
L*	53.78 ±0.69^{ab}	50.68±0.97^{b}	50.37±0.40^{b}	54.71±1.82^{a}	54.52±2.09^{a}
a*	5.83±0.92^{a}	5.96±0.22^{a}	5.54±0.05^{a}	5.94±0.84^{a}	6.31±0.98^{a}
b*	20.05±1.19^{a}	19.03±0.38^{a}	19.29±0.39^{a}	20.81±1.10^{a}	21.78±1.24^{a}
Texture profile analysis					
Hardness (kg)	9.07±1.34^{c}	11.30±1.82^{bc}	15.20±0.29^{ab}	15.07±2.16^{ab}	16.52±1.60^{a}
Springiness	0.72±0.07^{b}	0.73±0.06^{b}	0.76±0.02^{ab}	0.83±0.02^{ab}	0.86±0.02^{a}
Cohesiveness	0.40±0.02^{c}	0.44±0.03^{c}	0.43±0.01^{bc}	0.47±0.01^{ab}	0.50±0.02^{a}
Gumminess (kg)	3.62±0.72^{b}	4.86±1.24^{ab}	6.64±0.30^{ab}	7.16±1.25^{a}	7.83±1.74^{a}
Chewiness (kg)	2.66±0.79^{c}	3.52±1.12^{bc}	5.04±0.34^{abc}	5.83±0.93^{ab}	6.98±1.35^{a}
Proximate composition					
Moisture (%)	57.20±1.31^{a}	56.28±1.02^{a}	56.26±1.41^{a}	58.09±0.25^{a}	58.41±0.61^{a}
Protein (%)	17.77±0.91^{bc}	17.64±0.83^{bc}	16.09±0.06^{c}	18.98±1.18^{ab}	20.28±0.51^{a}
Fat (%)	17.40±0.03^{a}	16.38±0.20^{ab}	15.60±1.08^{b}	15.12±0.58^{b}	15.47±0.06^{b}
Fiber (%)	0.02±0.03^{a}	0.58±0.46^{a}	0.45±0.07^{a}	0.02±0.01^{a}	0.01±0.00^{a}
Ash (%)	2.18±0.07^{a}	2.31±0.34^{a}	3.16±0.59^{a}	2.28±0.03^{a}	2.03±0.12^{a}
Carbohydrate (%)	5.44±0.32^{a}	6.81±1.76^{a}	8.44±0.38^{a}	5.52±1.54^{a}	3.76±0.99^{a}
Sensory attributes					
Color	6.4±1.4^{b}	6.2±1.6^{b}	6.0±1.7^{b}	7.1±1.3^{a}	6.9±1.4^{a}
Flavor	6.6±1.2^{a}	6.3±1.3^{a}	5.8±1.6^{b}	6.4±1.2^{a}	5.7±1.4^{b}
Taste	6.7±1.4^{a}	5.9±1.6^{b}	4.8±1.7^{d}	6.4±1.4^{ab}	5.4±1.5^{c}
Tenderness	7.3±1.1^{a}	6.3±1.4^{b}	5.4±1.7^{c}	6.5±1.3^{b}	5.7±1.5^{c}
Juiciness	7.1±1.0^{a}	6.4±1.2^{b}	5.1±1.6^{d}	6.5±1.2^{b}	5.6±1.5^{c}
Overall acceptability	6.8±1.4^{a}	6.3±1.3^{b}	5.1±1.6^{d}	6.6±1.2^{ab}	5.6±1.3^{c}

Values are mean±standard deviations; Means within each row not having the same superscript differ significantly ($p<0.05$); Treatments Control = Not added rice bran or pea protein, T1 = 5% Rice bran flour, T2 = 10% Rice bran flour, T3 = 5% Pea protein, T4 = 10% Pea protein

L* (lightness), a* (redness) and b* (yellowness) of cooked pork patties and pork meatballs with various amounts of rice bran flour and pea protein are shown in Tables 2 and 3. For the cooked pork patties, there was not significant difference between the control and treatments in a* and b* values (p>0.05). L* and a* values were no statistically significant differences between the control and the treated samples of pork meatballs (p>0.05).

Table 3. Color, texture profile analysis, proximate composition and sensory attributes of cooked pork meatballs varied with the addition of rice bran flour and pea protein

Parameters	Treatments				
	Control	T1	T2	T3	T4
Color					
L*	40.27 ± 1.65^{a}	38.01 ± 1.18^{a}	36.92 ± 2.02^{a}	41.40 ± 2.47^{a}	41.36 ± 0.80^{a}
a*	6.08 ± 0.99^{a}	6.67 ± 2.02^{a}	7.44 ± 1.59^{a}	7.31 ± 1.25^{a}	7.94 ± 0.76^{a}
b*	18.14 ± 1.38^{abc}	17.62 ± 1.86^{bc}	16.75 ± 0.90^{c}	20.51 ± 0.81^{ab}	21.06 ± 0.57^{a}
Texture profile analysis					
Hardness (kg)	12.36 ± 1.61^{b}	14.15 ± 1.87^{ab}	16.39 ± 1.37^{ab}	16.97 ± 1.09^{ab}	17.54 ± 2.44^{a}
Springiness	0.81 ± 0.01^{ab}	0.83 ± 0.04^{ab}	0.78 ± 0.06^{b}	0.85 ± 0.04^{ab}	0.90 ± 0.02^{a}
Cohesiveness	0.52 ± 0.00^{b}	0.50 ± 0.04^{b}	0.48 ± 0.02^{b}	0.55 ± 0.00^{ab}	0.61 ± 0.05^{a}
Gumminess (kg)	6.45 ± 0.80^{c}	7.04 ± 1.50^{bc}	7.86 ± 1.04^{bc}	9.36 ± 0.59^{ab}	11.52 ± 0.64^{a}
Chewiness (kg)	5.25 ± 0.74^{b}	5.85 ± 1.45^{b}	6.20 ± 1.25^{b}	7.93 ± 0.81^{ab}	10.28 ± 0.81^{a}
Proximate composition					
Moisture (%)	48.16 ± 0.20^{c}	49.75 ± 2.33^{bc}	50.10 ± 1.17^{abc}	53.06 ± 0.10^{a}	51.92 ± 0.10^{ab}
Protein (%)	21.68 ± 0.84^{b}	17.98 ± 0.27^{c}	18.10 ± 0.01^{c}	22.81 ± 0.91^{ab}	25.15 ± 1.65^{a}
Fat (%)	23.61 ± 0.37^{a}	20.24 ± 0.73^{b}	18.88 ± 0.28^{bc}	16.58 ± 1.82^{cd}	15.97 ± 0.63^{d}
Fiber (%)	0.02 ± 0.02^{c}	0.40 ± 0.10^{b}	0.70 ± 0.09^{a}	0.03 ± 0.01^{c}	0.03 ± 0.01^{c}
Ash (%)	2.33 ± 0.34^{a}	2.61 ± 0.57^{a}	3.29 ± 0.13^{a}	3.19 ± 1.13^{a}	3.34 ± 1.32^{a}
Carbohydrate (%)	4.20 ± 0.60^{a}	9.01 ± 2.67^{a}	8.94 ± 0.86^{a}	4.33 ± 0.32^{a}	3.58 ± 3.72^{a}
Peroxide value (meq /kg)	6.54 ± 0.03^{a}	5.91 ± 0.66^{a}	4.62 ± 1.53^{ab}	5.88 ± 0.86^{a}	3.19 ± 0.58^{b}
Sensory attributes					
Color	6.8 ± 1.0^{a}	6.1 ± 1.2^{b}	4.0 ± 1.7^{c}	6.9 ± 1.1^{a}	6.9 ± 1.1^{a}
Flavor	6.8 ± 1.2^{a}	6.4 ± 1.2^{a}	4.7 ± 1.6^{c}	6.5 ± 1.3^{a}	5.9 ± 1.6^{b}
Taste	7.0 ± 1.2^{a}	6.6 ± 1.4^{b}	4.6 ± 1.7^{d}	6.7 ± 1.1^{ab}	5.9 ± 1.3^{c}
Tenderness	6.7 ± 1.1^{a}	6.2 ± 1.2^{b}	4.4 ± 1.5^{c}	6.5 ± 1.2^{ab}	6.1 ± 1.4^{b}
Juiciness	6.9 ± 1.1^{a}	6.3 ± 1.2^{bc}	4.1 ± 1.6^{d}	6.6 ± 1.2^{ab}	6.1 ± 1.2^{c}
Overall acceptability	7.1 ± 1.1^{a}	6.5 ± 1.3^{bc}	4.3 ± 1.4^{d}	6.8 ± 1.0^{ab}	6.3 ± 1.1^{c}

Values are mean ±standard deviations; Means within each row not having the same superscript differ significantly (p<0.05); Treatments Control = Not added rice bran or pea protein, T1 = 5% Rice bran flour, T2 = 10% Rice bran flour, T3 = 5% Pea protein, T4 = 10% Pea protein

Peroxide value analysis was carried out of oil used in frying the pork meatballs. The oil used for pork meatballs with the higher level of rice bran flour and pea protein had reduced peroxide values (Table 3). The sensory scores for pork patties and pork meatballs ewas shown in Tables 2 and 3. The pork patties and the pork meatballs using the rice bran and the pea protein at 5% level had overall acceptability scores most similar to the control at 6.3-6.8, which means the panelists found them acceptable. When increased to 10% the sensory evaluation score decreased.

Discussion

The addition of rice bran flour and pea protein increased cooking yield, moisture retention and fat retention, there have been shown to improve cooking properties in pork patties and meatballs and to have effective water holding and fat binding capacities (Chandi and Sogi, 2007; Reinkensmeier *et al*., 2015; Osen *et al*., 2014). This result is similar to the finding of El-Magoli *et al*. (1996), Gao *et al*. (2014), Gujral *et al*. (2002), Serdaroğlu (2006) and Serdaroğlu and Değirmencioğlu (2004).

Addition of rice bran decreased the L* and b* values and increased the a* values. Gao *et al*. (2014) obtained similar results with rice flour added to ground pork patties. Increasing the pea protein raised the L*, a* and b* values compared to the control. Pietrasik and Janz (2010) reported that the addition of pea ingredients had minimal effects on the color of beef bologna. This might be a result of the carotenoid pigments in the rice bran flour and pea protein.

Rice bran flour and pea protein also affected textural properties of the pork patties and pork meatballs. Pea protein at 10% showed the highest texture evaluation factors. Huang *et al*. (2005) showed similar results when the studying the effects of adding rice bran to emulsified pork meatballs. This result agrees with the results of Pietrasik and Janz (2010) who found that the addition of pea ingredients improved the textural properties of beef bologna. However, Gao *et al*. (2014) reported that glutinous rice flour reduced the hardness, springiness and chewiness of pork patties. Adding rice bran and pea protein to make pork patties and pork meatballs can imrove its nutritional value. Similar results were reported by Huang *et al*. (2005) and Pietrasik and Janz (2010).

Peroxide value of oil used in frying the pork meatballs decreased with increase level of rice bran and pea protein. It indicated the better frying stability of rice bran oil. Product prepared using rice bran flour and pea protein had lower amounts of lean meat, and therefore lower iron in the myoglobin, which reduced the activation of the oxidation reaction. Iron and iron-containing haem pigments have been shown to be a major factor in activation of the oxidation reaction (Warriss, 2000). There was significant difference among the pork patties and pork meatballs in respect to sensory properties, but the addition of 5% of rice bran flour and pea protein led to acceptable products and can be recommended in the traditional meatball production. Choi *et al*. (2008) obtained similar results for emulsion type sausages.

Acknowledgement

This research was thank Thai Edible oil Co., Ltd. for funding and supplying important raw materials: the rice bran flour, the pea protein and rice bran oil.

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(Received: 30 August 2019, accepted: 25 February 2020)