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Effects of Powder from *Passiflora Edulis* Peel on Dough Properties and Bread Quality

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ABSTRACT

In this work, we aimed to experimentally investigate the influences of the addition of passion fruit powder on finished bread characteristics, i.e., the quality and sensory perception, and the dough physical-chemical properties. The substitution rate of the passion fruit peel powder ranged from 5 to 20% of the wheat flour by weight. In order to study the dough properties, various parameters such as the moisture content, gluten content, yeast gas production, and dough structure were evaluated. Additionally, the finished bread characteristics, e.g., the color, flavor, and nutritional content, were also assessed and analyzed. Results showed that the dough properties and bread structure were strongly dependent on the amount of passion fruit peel powder added. For instance, the volume of bread was observed to be dramatically reduced with the increasing substitution rate of the passion fruit peel powder. Moreover, the polyphenol contents in bread samples were 1355 mg/kg, 1637 mg/kg, 1773 mg/kg, and 1838 mg/kg for the substitution rate of 5%, 10%, 15%, and 20%, respectively. Amongst these, the bread with 10% passion fruit peel powder was the most preferred sample.

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1. Introduction

Fruit peels discarded from industrial production activities have been considered as one of the major sources of dietary fiber thanks to efficient antioxidant activities of polyphenolic components (phenolic acid and flavonoids) contained in them. Amongst various fruit peels, passion ones have recently drawn great attention and are widely utilized in the manufacture of pectin as a food additive [1]. This is probably due to the high content of polyphenolic compounds including numerous hydroxyl groups in the passion fruit, thereby significantly increasing the antioxidant capacity and free radical scavenging activity of phenolic compounds [2]. In addition, thanks to the unique flavor and nutritional qualities, the purple passion fruit (*Passiflora edulis*) is economically important in tropical areas. The abundant phenolics found in the peel and pulp of passion fruit can result in various health benefits. Moreover, passion fruit peel powder can be efficiently used for waste recycling on organic farms as a nutritious culinary component.

In fact, numerous materials such as coffee grounds, okara, barley, and maize were used to partially replace wheat flour in bread production [3] - [4]. Passion fruit peel powder has been studied and added to pastas, biscuits, yogurt… but has not been added to bread products [15], [20], [35]. Hence this study aimed to investigate the influences of supplementation of passion fruit peel powder on the dough quality and the finished bread products including textural, nutritional and sensorial properties.

2. Materials and Methods

2.1. Materials

The peels of purple passion fruits were collected and undergone several processing stages to transform into the powder form. The peel separated from the mucus layer were cut into 1 x 2 cm pieces and then drained for 12 hours. The pieces were dried at 70 °C for 8 hours using a convection oven

(Memmer UN110, Germany). The dried samples were ground using a pulverizer (OEM 800Y, China). After that, the passion fruit peel powder (moisture content was from 5 – 8%) was passed through a 0.5 mm mesh size [5]. The passion fruit peel powder (PFPP) was preserved in PE airtight bags and stored at room temperature.

2.2. Experimental approach

Bread samples supplemented with PFPP were prepared according to the following procedure.

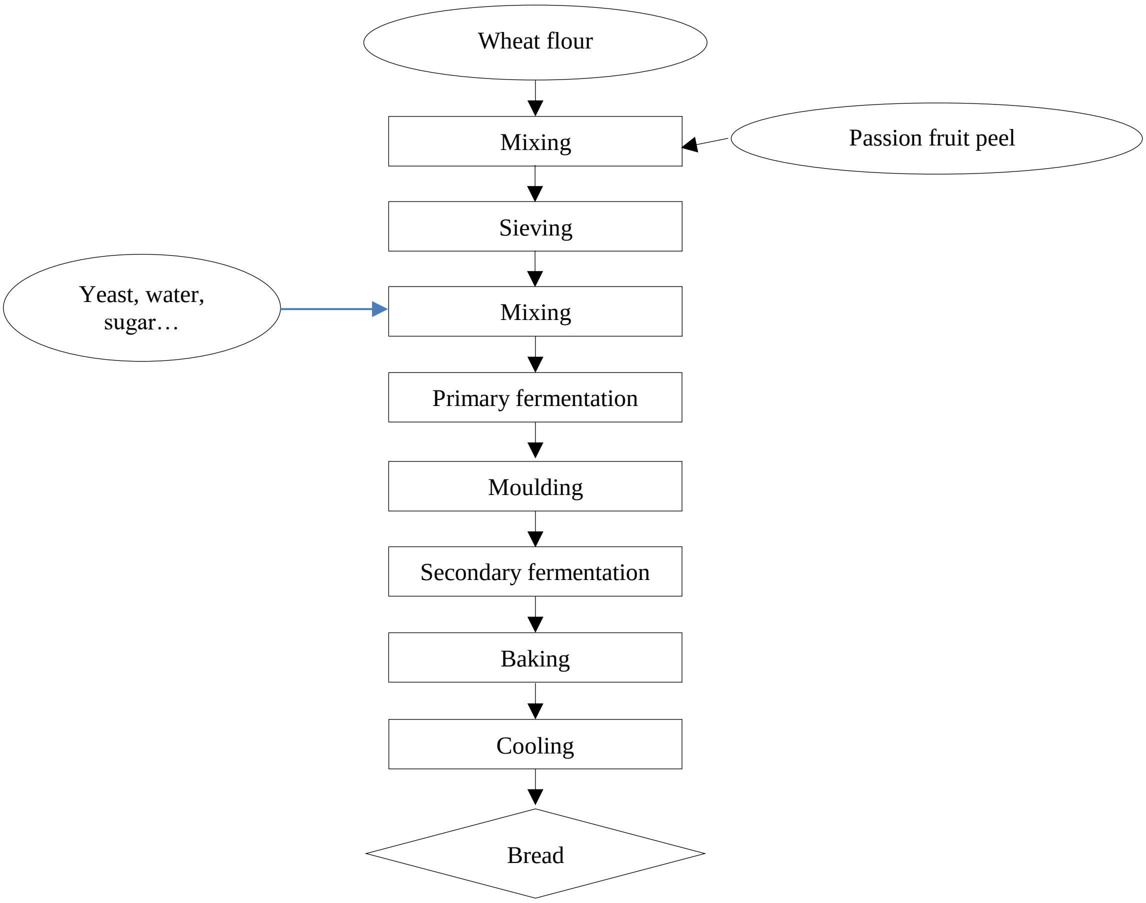

Figure 1. *Process of making bread sample with PFPP added in this study.*

2.3. Quality assessment of bread dough

2.3.1. Wet gluten content

The wet gluten content was determined according to method of [6]. The wet gluten content was calculated as follows:

$$X_1 = \frac{100 \times m_2}{m_1} \quad (1)$$

where m_1 is the dough weight (20 g); m_2 (g) is the weight of wet gluten obtained after washing.

2.3.2. Dry gluten content

Dry gluten content was determined according to [6]. The wet gluten was dried at 105 °C until a constant weight was reached. The dry gluten content was calculated as follows:

$$X_2 = \frac{m_3 - m_4}{m_2} \times 100\% \quad (2)$$

where m_2 is the wet gluten content (g); m_3 (g) and m_4 are the total weight of wet gluten and its container before and after drying, respectively.

2.3.3. Moisture content of dough

The dough is dried to a constant weight to estimate its moisture content; more details can be referred to [7].

2.4. Quality assessment of bread

2.4.1. Specific bread volume

The specific gravity of the bread sample is estimated as:

$$d\ (\frac{g}{cm^3}) = \frac{M}{V_2} \times 100 \qquad (3)$$

where M (g) is the bread weight after baking process; V (cm^3) is the volume of bread determined by method reported by [6].

2.4.2. Color of the crumb

The color variation of the bread was measure using a color meter named Chroma meter Minolta CR-400 [8]. The color difference, ΔE, is expressed as:

$$\Delta E = [(L_s - L)^2 + (a_s - a)^2 + (b_s - b)^2]^{1/2} \qquad (4)$$

with $L_s = 25.54$, $a_s = 28.89$, $b_s = 12.03$. Moreover, L (0-100) is the brightness; a and b are respectively the redness/greenness and yellowness/blueness of samples.

2.4.3. Nutritional content

The calorie content and carbohydrate content of bread samples were analyzed according to Food and drugs Administration Method [7]; the protein content was measured by the Kjeldahl method (AOAC 992.23); lipid content was determined by Soxlet method [7]; the polyphenols content was analyzed by ISO 14502 – 1:2005 [9]; the soluble fiber content was analyzed by AOAC 991.43.

2.4.4. Texture analysis of dough/bread substitutes

To investigate the textural properties of a sample, a double compression approach, i.e, Texture Principle Analysis (TPA), was employed. Additionally, XA.XTPlus Texture Analyser software was utilized to collect data [10]. Parameters including hardness, cohesiveness, springiness, gumminess, and chewiness were recorded and then analyzed [10].

2.4.5. Sensory evaluation

The bread sample is rated as a favorite by ranking test [12].

2.5. Statistical data analysis

The data were analyzed using SPSS and Excel 2010. The variance analysis method ANOVA was used to evaluate the differences among samples.

3. Results and Discussion

In this part, the effects of added PFPP on the dough quality (i.e., gluten content) and bread characteristics (i.e., volume, colour, structure, nutritional and polyphenol contents, and consumer taste) are presented and analyzed in detail.

3.1. Dough quality

Table 1. *Moisture and gluten contents of bread dough*

Sample	Dough moisture (%)	Wet gluten (%)	Dry gluten (%)
Control	$48.12^a \pm 0.21$	$14.23^a \pm 0.25$	$11.30^a \pm 0.30$
P5	$47.90^a \pm 0.12$	$13.13^b \pm 0.23$	$10.47^b \pm 0.45$
P10	$46.84^b \pm 0.23$	$12.40^c \pm 0.36$	$9.57^c \pm 0.12$
P15	$46.38^b \pm 0.42$	$9.17^d \pm 0.29$	$6.10^d \pm 0.36$
P20	$45.81^c \pm 0.58$	$7.40^e \pm 0.17$	$4.47^e \pm 0.58$

Note: P5, P10, P15, P20 are bread dough samples with wheat flour replacement by PFPP of 5%, 10%, 15% and 20%, respectively.

As can be observed in Table 1, an increase in PFPP resulted in a considerable reduction in the dough moisture and/or the wet and dry gluten contents. This could be attributed to the high fiber content in PFPP. In detail, fibers can absorb a large amount of water, competing with starch granules and then decreasing the dough moisture content and preventing gluten formation [13] – [14]. It is necessary to mention that Ribeiro [15] created a gluten-free fresh pasta product with 10% peel powder to demonstrate the gluten-free characteristics of this flour.

The addition of PFPP was also proved to reduce the gluten level of bread dough. Compared to the moisture content of popular bread frequently ranging from 45-49% for a well-structured sample [16], our dough sample with added PFPP had a relatively lower values (see Table 1).

3.2. Characteristics of bread supplemented with PFPP

3.2.1. Bread volume

Table 2. *Physical parameters of bread with passion fruit peel powder*

Sample	Weight (g)	Volume (cm^3)	Specific gravity (g/cm^3)
Control	16.01^a ± 0.06	71.67^a ± 3.58	0.23^a ± 0.02
P5	16.19^b ± 0.51	55.00^b ± 2.70	0.29^b ± 0.02
P10	16.85^c ± 0.13	38.33^c ± 1.89	0.44^c ± 0.02
P15	16.24^b ± 0.04	33.33^d ± 1.57	0.49^c ± 0.03
P20	16.31^b ± 0.09	31.67^d ± 1.49	0.52^c ± 0.04

Note: P5, P10, P15, P20 are bread samples with wheat flour replacement by PFPP of 5%, 10%, 15% and 20%, respectively.

It was found that substituting 20% of wheat flour with PFPP resulted in an overall volume reduction of up to 2.3 times as compared to the Control sample (Table. 2). According to Wang [17], the addition of fiber to bread also resulted in the reduction in bread volume [18]. As a result of adding PFPP to the dough, the dough's moisture content decreased, hence the dough had a greater consistency and tended to more tightly enclose air bubbles. This caused the dough to have a higher mass and, as a result bread product become denser in texture [19].

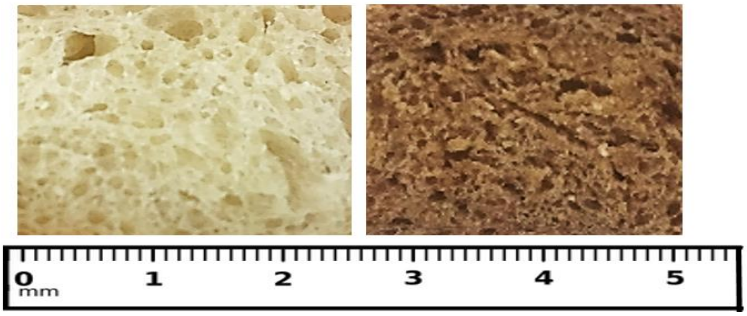

Figure 2. *Slice of bread structure of control sample (left) and 20% sample (right)*

Generally, the bread weight tended to be slightly increased with the increasing rate of PFPP used; this is probably due to the reduction in the air holding capacity of the dough during the yeast fermentation. The bread volume, however, seemed to be dramatically decreased as the rate of PFPP increased. For instance, the bread volume with a rate of 20% PFPP substitution was reduced by 2.3 times compared to that with 10% PFPP. This is because the addition of PFPP led to a greater dough density, thereby enclosing air bubbles more securely during handling. The dough hence had higher mass as stated above and became denser. Our findings were well in line with those obtained in [17] – [18]. Furthermore, with an increase in the wheat flour replacement ratio, the bread density gradually increased due the high reduction in bread volume (from 0.2249 to 0.5178). The density of the sample containing 20% PFPP was 2 times larger than that of the control sample (see Figure 2).

3.2.2. Bread colour

Table 3. *Results of bread colour measurement*

Sample	(%)	L	A	B	ΔE
Control	0	63.91^a ± 1.57	- 0.19^a ± 0.01	14.25^a ± 0.70	29.05
P5	5	55.54^b ± 1.53	3.19^b ± 0.06	14.72^a ± 0.58	36.20
P10	10	49.43^c ± 0.58	5.36^c ± 0.24	15.07^a ± 0.38	41.85
P15	15	47.77^c ± 0.99	6.44^d ± 0.19	15.23^b ± 0.22	43.52
P20	20	43.94^d ± 0.19	7.26^e ± 0.25	15.48^b ± 0.24	46.75

Table 3 shows the results for bread colour measurement. It is evident that the values of *L*, *a*, and *b* differed significantly as the replacement rate of PFPP increased. Specifically, the higher amount of PFPP added, the greater *L* and the lower *a* and *b* were observed, leading to the lower brightness and the darker the brown-orange hue of the product [20] – [21]. Since the color difference *ΔE* is larger than 5 for all the cases investigated, it is reasonable to conclude that an obvious color variation was observed [22].

3.2.3. Bread texture

Table 4. *Texture properties of bread crumb*

Sample	Cohesiveness	Springiness (mm)	Hardness (gram)
Control	0.70^a ± 0.02	7.60^a ± 0.14	448.00^a ± 21.08
P5	0.71^{ab} ± 0.02	7.54^{ab} ± 0.21	500.80^b ± 25.03
P10	0.72^{ab} ± 0.02	7.51^{ab} ± 0.15	569.00^c ± 22.53
P15	0.73^{bc} ± 0.03	7.46^{ab} ± 0.14	606.90^c ± 28.96
P20	0.75^c ± 0.03	7.41^b ± 0.15	728.10^d ± 33.55

Results for textural properties of bread crumb are provided in Table 4. The hardness of bread with added PFPP was much different from the control sample. The hardness of bread rose from 448.0 g in the control sample to 500.8 g, 569.0 g, 606.9 g, and 728.1 g with the substitution rate of PFPP of 5%, 10%, 15%, and 20%, respectively. The soluble fibers in PFPP could complete with gluten proteins for water, hence inhibiting the gluten network development. Additionally, gluten network structure is supposed to affect the cohesiveness and elasticity; specifically, it is revealed that cohessiveness and elasticity varied by 20% in the sample. Therefore it is suggested that the substitution of PFPP should be less than 20% in order to avoid affecting the bread texture.

3.2.4. Nutritional content

Table 5. *Nutritional content of a control bread sample (0% replacement)) and P10 sample (10% of wheat flour was replaced by PFPP)*

	Unit	Control	P10
Calorie	Kcal/100g	310^a ± 4.48	320^b ± 3.03
Carb	%	77.9^a ± 3.89	65.9^b ± 3.29
Protein	%	9.96^a ± 0.45	9.42^a ± 0.47
Lipid	%	7.92^a ± 0.23	6.28^b ± 0.12
Fiber	%	1.82^a ± 0.09	3.67^b ± 0.15

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Results in Table 5 show that bread containing 10% PFPP had lower calorie, carbohydrate, and fat contents; however, the energy difference was negligibly small. Hence, the inclusion of passion fruit peel powder results in a product with minimal carbohydrate and fat contents while possibly retaining the necessary protein and calorie contents. Moreover, the fiber content of a bread with 10% PFPP was two times larger than that of the control one. It is worth noting that the higher the fiber consumption, the larger the daily intake of dietary fiber [23] and the less blood cholesterol, blood sugar, and insulin, reducing the risks of cardiovascular disease [24]. This product is, hence, strongly recommended for dieters [25].

The energy value and the carbohydrate content of P10 bread were 320 kcal and 65.9%, respectively; which were similar to those obtained by Oliveira (326 kcal and 68.9%) [26]. The energy value of carbohydrate content of M10 were slightly different from those of control sample. This could be because the in bread making process, PFPP supplemented bread dough underwent 3 stages of incubation at normal temperature for a long time, hence creating favorable conditions for yeast and carbohydrate-degrading microorganisms. Additionally, peel powder had lower carbohydrate content (72.7%) than wheat flour (73.6%), which can be a reason for a lower carbohydrate in M10 sample.

P10 sample also had 3.67 g of fiber per serving, making it a good source of fiber (with 2.5 g of fiber per serving) [27]. The amount of fiber content was increased by 121% as compared to the control sample, and 2.8 times higher than that of Oliveira's work [số tài liệu tham khảo của Oliveira]. Garcia also discovered a significant fiber content when adding PFPP [28].

3.2.5. Polyphenol content

As found in previous works, the polyphenol content of passion fruit peel was higher than that of guava, apples, pears, papaya, and a variety of other tropical fruits [29]. The polyphenol content of passion fruit peel powder was 0.53 g/100g (5300 mg/kg), which was 7-13 times greater than the total polyphenol content of peanut shell (428.1 - 739.8 mg/kg) [30], two times higher than the orange peel polyphenols (2578 mg/kg) [31], four times higher than polyphenol content of sweet potatoes (1360.5 mg/kg) [32], and 1.5 times higher than that of fig pods [33]. The polyphenol concentration of PFPP in this study was similar to that found in Morais' study (5040.6 mg/kg) [34].

In general, the polyphenol content in bread increased substantially (see Table 6). The equivalent polyphenol contents were 1355, 1637, 1773, and 1838 mg/kg when PFPP was added to bread with substitution rates of 5%, 10%, 15%, and 20%, respectively. The polyphenol contents of the bread samples increased with the increasing PFPP substitution. Thus, the PFPP addition to bread increased the polyphenol content, thereby improving bread quality.

Table 6. *Polyphenol content in bread with passion fruit peel powder*

Sample	Control	P5	P10	P15	P20
Polyphenol (mg/kg)	0	1355	1637	1773	1838

3.2.6 Sensory evaluation

Table 7. *Results of sensory ranking test for bread products supplemented with passion fruit peel powder*

Sample	Favorite level of bread products
Control	$4.23^a \pm 1.28$
P5	$3.14^b \pm 1.08$
P10	$3.35^b \pm 1.02$
P15	$2.18^c \pm 1.14$
P20	$2.01^c \pm 1.19$

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As revealed in Table 7, control sample (0% PFPP) was the most favored, followed by the P5 sample and P10 sample. Samples P15 and P20 were less preferable. Panelists tend to prefer samples added a small amount of PFPP. Based on the sensory evaluation results, it could be concluded that the bread sample with 10% of passion fruit peel powder was the most acceptable. In terms of organoleptic examination, bread samples containing passion fruit peel powder were deemed acceptable. Nevertheless, color and flavor qualities must be enhanced, particularly in an effort to minimize bitterness [35].

4. Conclusions

As observed, the addition of passion fruit peel powder altered the dough characteristics and texture of the bread. The replacement of 10% wheat flour in formulation by PFPP did not greatly affect the sensorial quality of P10 bread. Moreover, the addition of passion fruit peel powder to the bread substantially improved the bread color, hence boosting its appearance. The nutritional values of PFPP bread were also noticeably greater than those of control bread sample. Furthermore, the nutritional analysis revealed the presence of fiber with a content of 3.67% (soluble fiber reaching 1.92%) in the bread sample supplemented with 10% PFPP. In addition, passion fruit peel powder contains up to 0.53 g/100g of polyphenols - substances with significant biological activity. Therefore, the addition of passion fruit peel powder to bread shows great potential for the future development of passion fruit peel bread to diversify goods and increase the nutritional content of traditional bread products.

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