FUNCTIONAL PROPERTIES AND INFLUENCES OF COCONUT FLOUR ON TEXTURE OF DOUGH AND COOKIES

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ABSTRACT

Coconut flour, a significant byproduct of coconut milk and oil productions, is rich in fiber and protein. It can be utilized as an alternative material for cookies products. This paper focused on the functional properties of coconut flour and effect of coconut flour supplement on texture of dough and cookies. Results indicated that hydration properties and oil binding capacity (OBC) were significantly influenced by size of particles in coconut flour. With increase in size of coconut flour, water absorption capacity (WAC) and swelling capacity (SC) values increased; whereas, OBC value decreased. Maximum value of water retention capacity (WRC) was observed at 0.20–0.25 mm of particle size. Adding coconut flour into dough caused enhancement of hardness, cohesiveness and adhesiveness; whereas, insignificantly influenced on springiness. In addition, adding coconut flour led to decrease in spread ratio and increase in hardness of cookies. The results can be applied for substitution of coconut flour for wheat flour in cookies processing.

Keywords: coconut flour, cookies, dough, texture properties, functional properties.

1. INTRODUCTION

Cookies is one of the staple bakery products. Normally, it is made from wheat flour. Nevertheless, gluten in wheat can cause a celiac disease, characterized by damage of small intestinal mucosa caused by gliadin fraction of wheat in susceptible people [1]. Celiac disease can be treated by using gluten-free materials which substitute for wheat flour.

Coconut (Cocos nucifera) is popular in tropical regions, such as: South and Southeast Asia, Africa, Central America, etc. Matured coconut endosperm is rich in lipid, protein and fiber [2]. Recently, it has been extracted for manufacturing coconut milk (including concentrate and powder products) and oil for food and cosmetic. Nevertheless, there is a large amount of residue waste from production of these products. This residue is rich in fiber, carbohydrate and protein. It is utilized for production of coconut flour. Some authors reported that coconut flour can be utilized as a substitutive material for wheat flour in bread [3], noodle [4]. Sridevi (2013) reported that coconut flour could substitute for 25% of wheat flour in cookies [5]. These reports implied
that coconut flour could contribute to, not only treat celiac disease, but also enhance added value of coconut nut.

Arunugam et al. (2014) reported the water holding and retention capacities of coconut flour but have not investigated the influence of the size of particles on these properties yet [6]. Raghavendra et al. (2004) showed that particle sizes in range of 390–1,127 μm significantly influenced on hydration properties of coconut flour [7]. Although coconut flour has been applied for cookies processing, the texture properties of dough and cookies with adding coconut flour were not studied [5].

The aim of this paper is to study the effects of particle size of coconut flour on its functional properties, including: water and oil absorption, swelling capacity and water retention. In addition, the texture properties of dough and cookies with adding coconut flour was also investigated.

2. MATERIALS AND METHODS

2.1. Materials

Coconut flour: Coconut (Cocos nucifera) was purchased from local farm in Ben Tre Province (Vietnam). It was 10–12 months of age. Coconut was husked, shelled, pared. Then, it was grated with grater made by Nhat Minh Thanh Ltd. and the particle size of grated coconut meat was 1 mm. Approximately, from 3 coconut fruits, 1,000 gram of grated coconut was obtained. The grated coconut meat was added water with ratio of grated coconut meat to water being 1:1 (w:w). The mixture was mixed and pressed by hydraulic press. From 1,000 grams of grated coconut meat, 450 grams of coconut flour (50.1 % w/w of moisture) was recovered. Coconut flour was dried by hot air at 60 °C in 3 hours in cabinet dryer with 1 cm of thickness of flour layer. Moisture of final coconut flour was 6.13 %.

Size fractions of coconut flour: The sieving was applied with Vibratory Sieve Shaker Analysette 3 Pro (Fritsch, German) for classifying coconut flour into ranges of size. This machine was equipped 5 sieves with following sizes of sieve opening: 450, 350, 250, 200, and 180 μm. The oscillation and time were 4 mm and 5 minutes, respectively. The coconut flour from these size fractions was analyzed functional properties.

Dough preparation: Coconut flour was mixed with wheat flour with different ratios (in range of 0–35 % w/w). Then, the mixture of flour was mixed with the other ingredients as in Table 1. The mixture was kneaded in 2 minutes, followed by incubating in 10 minutes.

Cookies preparation: The dough was sheeted and formed in circle with diameter and thickness of 4 cm and 0.5 cm, respectively. It was baked in electrical oven at 180 °C in 7 minutes.

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Coconut – wheat mixture</th>
<th>Sugar</th>
<th>Egg</th>
<th>Shortening</th>
<th>Salt</th>
<th>Lecithin</th>
<th>Baking powder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount</td>
<td>44 %</td>
<td>23</td>
<td>10.6</td>
<td>21.2</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
</tr>
</tbody>
</table>
2.3. Proximate analysis

Moisture: Moisture of flour was determined by TCVN 9706:2013, protein - AOAC 992.23 method (Kjeldahl method) (AOAC, 2000), lipid - AOAC 920.85 method (Soxhlet method) (AOAC, 2000), ash - AOAC 923.03 method (AOAC, 2000), fiber - AOAC 962.09 method (AOAC, 2000),

Carbohydrate: Carbohydrate was determined as the following equation [4]:

\[
\text{Carbohydrate}(\%) = 100 - \text{lipid}(\%) - \text{protein}(\%) - \text{fiber}(\%) - \text{ash}(\%)
\]

2.4. Water absorption capacity (WAC)

1 gram of coconut flour was taken in a tube, and 30 mL of water was added. The mixture was kept at ambient temperature in 18 hours. Then, it was drained by filtrate under vacuum pressure and determined the weight of hydrated flour. Finally, to determine the dry weight of flour, hydrated flour was dried at 105 °C until constant mass was obtained [7]. WAC was determined as the following equation:

\[
\text{WAC}(g/g) = \frac{\text{Mass of hydrated flour (g)} - \text{Mass dried flour (g)}}{\text{Mass of dried flour (g)}}
\]

2.5. Water retention capacity (WRC)

1 gram of coconut flour was taken in a tube, and 30 mL of water was added. The mixture was kept at ambient temperature in 18 hours. Then, it was centrifuged at 3,000 g in 20 minutes. The supernatant was removed by drainage with vacuum filtration and determined the weight of hydrated flour. Finally, to determine the dry weight of flour, hydrated flour was dried at 105 °C until constant mass was obtained [7]. WRC was determined as the following equation:

\[
\text{WRC}(g/g) = \frac{\text{Mass of hydrated centrifuged flour (g)} - \text{mass of dried flour (g)}}{\text{Mass of dried flour (g)}}
\]

2.6. Swelling capacity (SC)

0.2 gram of coconut flour was placed into the tube. Then, adding 10 mL of water and keeping at ambient temperature in 18 hours. Finally, volume attained by hydrated flour was determined [7]. SC was determined as the following equation:

\[
\text{SC (mL/g)} = \frac{\text{Volume of hydrated flour}}{\text{Mass of flour (g)}}
\]

2.7. Oil binding capacity (OBC)

1.0 gram of coconut flour and 20 mL were placed in centrifugal tube. The mixture was vortexed for 1 minute; then, kept for 60 minutes at ambient temperature. Then, it was centrifuged at 4,000 g in 30 minutes. Supernatant was removed and weighing the oil- absorbed flour [8]. OBC was determined as the following equation:

\[
\text{OBC (g/g)} = \frac{\text{Mass of centrifuged flour (g)} - \text{Mass of flour (g)}}{\text{Mass of flour (g)}}
\]
2.8. Texture Profile Analysis

Texture profile of dough was analyzed by Instron Universal Testing Instrument (Model 5540) equipped flat-end cylinder probe. 5 dough pieces were used for texture analysis. The parameters of testing procedure were as follows: force: 1,000 N, speed of cross-head: 10 cm/minute, compression level: 80%. The thickness and diameter of dough were 3 cm and 1 mm [9].

Hardness of cookies: Hardness of cookies was analyzed by LFRA Texture Analyzer (Brookfield). The fixture was TA15/100 with distance and speed of probe being 2 mm and 4 mm/s, respectively. The tests were replicated 5 times.

2.9. Physical analysis

Diameter and thickness of cookies: Diameter and thickness of cookies were determined as the method proposed by Rao and Haridas (1997) [10].

Spread ratio: Spread ratio of cookies was determined as the following equation [10]:

\[
\text{Spread ratio (\(\text{cm}^{-1}\))} = \frac{\text{Diameter (cm)}}{\text{Thickness (cm)}}
\]

2.10. Statistical analysis

The means and standard deviations were determined for all the experiments. The significant difference of mean values was assessed with one-way analysis of variance (ANOVA) followed by Fisher’s test using Excel software ver.2010 at a significance level of \(P < 0.05\).

3. RESULTS AND DISCUSSION

3.1. Chemical composition of coconut flour

Chemical compositions of coconut flour were showed in Table 2. Results indicated that, obtained coconut flour was rich in lipid and fiber. Contents of lipid, protein, and fiber in coconut flour were 29.83 ± 0.52, 5.77 ± 0.18, and 19.82 ± 0.63 % w/w, respectively. Gunathilake (2009) reported that those of byproduct from extraction of coconut oil by screw extruder were 9.20, 12.60 and 13.20, respectively [3]. However, in residue of coconut milk extraction, the contents of lipid, protein, and fiber were of 42.60, 4.20 and 23.2, respectively [11]. These results indicated that compositions of coconut flour were influenced by the kinds of products manufactured from coconut endosperm. And, coconut flour contained the highly valuable components, such as: fiber, lipid, protein etc. which could be used for food.

Table 2. Chemical compositions of coconut flour.

<table>
<thead>
<tr>
<th>Composition</th>
<th>Moisture</th>
<th>Lipid</th>
<th>Protein</th>
<th>Ash</th>
<th>Fiber</th>
<th>Carbohydrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value (%)</td>
<td>6.13 ± 0.21</td>
<td>29.83 ± 0.52</td>
<td>5.77 ± 0.18</td>
<td>1.15 ± 0.01</td>
<td>19.82 ± 0.63</td>
<td>37.30</td>
</tr>
</tbody>
</table>
3.2. Influence of size on functional properties of coconut flour

Functional properties of coconut flour with different range of particle size were shown in Table 3. The result indicated that WAC and SC values were increased with increase in size of particles in coconut flour. The increase in WAC leads to the increase in SC due to the absorption of water in matrices of flour. WRC increased with increase in particle sizes from < 0.18 mm to 0.20–0.25 mm. With the particle size being larger than 0.25 mm, effect of particle sizes on WRC was insignificant (p < 0.05). OBC value decreased with increase in particle sizes of coconut flour. Guillon and Champ (2000) proposed that the change in microstructure of particle in grinding caused the changes in hydration properties and oil binding capacity [12]. Sangnark (2003) suggested that decrease in particle sizes resulted in modification of structure of carbohydrate matrices; consequently, particles could absorb less water [13]. Thus, it caused the change in hydration properties.

Table 3. Functional properties of coconut flour.

<table>
<thead>
<tr>
<th>Size (mm)</th>
<th>WAC (g/g)</th>
<th>WRC (g)</th>
<th>OBC (g/g)</th>
<th>SC (mL/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 0.18</td>
<td>7.91 ± 0.30a</td>
<td>5.94 ± 0.53b</td>
<td>3.93 ± 0.05a</td>
<td>10.31 ± 0.55a</td>
</tr>
<tr>
<td>0.18 – 0.20</td>
<td>8.31 ± 0.34a</td>
<td>7.66 ± 0.21a</td>
<td>3.84 ± 0.02a</td>
<td>11.77 ± 0.26a</td>
</tr>
<tr>
<td>0.20 – 0.25</td>
<td>10.87 ± 0.51b</td>
<td>10.35 ± 0.28a</td>
<td>3.64 ± 0.02a</td>
<td>12.91 ± 0.04ab</td>
</tr>
<tr>
<td>0.25 – 0.35</td>
<td>11.06 ± 0.32c</td>
<td>9.64 ± 0.50a</td>
<td>3.74 ± 0.11ab</td>
<td>12.44 ± 0.53bc</td>
</tr>
<tr>
<td>0.35 – 0.45</td>
<td>11.88 ± 0.20c</td>
<td>9.64 ± 0.25a</td>
<td>3.45 ± 0.09bc</td>
<td>13.45 ± 0.02cd</td>
</tr>
<tr>
<td>&gt;0.45</td>
<td>11.72 ± 0.44c</td>
<td>9.57 ± 0.02c</td>
<td>3.28 ± 0.12c</td>
<td>13.27 ± 0.60c</td>
</tr>
</tbody>
</table>

The mean ± standard deviation within a column with different uppercase superscript letters was significantly different (p < 0.05).

3.3. Influence of coconut flour on texture of dough

Influence of coconut flour on texture of dough was showed in Table 4. The increase in quantity of coconut flour in coconut flour–wheat mixture made hardness, cohesiveness and adhesiveness become higher.

Table 4. Influence of coconut flour on texture of dough.

<table>
<thead>
<tr>
<th>Percentage of coconut flour (°)</th>
<th>Hardness (N)</th>
<th>Cohesiveness (-)</th>
<th>Adhesiveness (N,s)</th>
<th>Springiness (-)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>80.51 ± 4.52a</td>
<td>0.42 ± 0.02a</td>
<td>6 ± 0.35ab</td>
<td>1.22 ± 0.014a</td>
</tr>
<tr>
<td>15</td>
<td>54.90 ± 2.61b</td>
<td>0.54 ± 0.009b</td>
<td>12 ± 3.64bc</td>
<td>1.21 ± 0.017a</td>
</tr>
<tr>
<td>20</td>
<td>77.22 ± 1.62a</td>
<td>0.56 ± 0.004c</td>
<td>14 ± 3.26c</td>
<td>1.22 ± 0.015a</td>
</tr>
<tr>
<td>25</td>
<td>92.67 ± 1.27c</td>
<td>0.60 ± 0.01d</td>
<td>31 ± 3.75d</td>
<td>1.22 ± 0.01d</td>
</tr>
<tr>
<td>30</td>
<td>118.15 ± 3.66d</td>
<td>0.61 ± 0.01d</td>
<td>33 ± 4.95d</td>
<td>1.23 ± 0.014a</td>
</tr>
<tr>
<td>35</td>
<td>135.49 ± 0.95e</td>
<td>0.62 ± 0.03d</td>
<td>37 ± 2.91d</td>
<td>1.26 ± 0.01a</td>
</tr>
</tbody>
</table>
The mean ± standard deviation within a column with different uppercase superscript letters was significantly different (p < 0.05).

(*) : Percentage of coconut flour in coconut – wheat mixture.

The higher content of coconut flour led to higher contents of fiber and carbohydrate which was, along with protein, responsible for structure of dough [14]. When adding 15 and 20 % of coconut flour into coconut flour– wheat mixture, hardness of dough was lower than that of control (without adding of coconut flour). However, adding 25 % or more coconut flour, the hardness of dough was higher than that of control. This phenomenon can be explained by network of gluten in dough which also contributes into the hardness of dough. In control sample, structure of dough was determined by network of gluten. The result also indicated that adding coconut flour was insignificantly influenced on springiness of dough.

3.4. Influence of coconut flour on texture properties of cookies

Influence of coconut flour on texture properties of cookies was showed in table 5. Adding more coconut flour caused the higher hardness value of cookies. It was explained that, after baking, hardness of cookies was determined by fiber and carbohydrate content [15]. Dehydration of fiber and carbohydrate established the matrices which contribute into structure of cookies. After baking, diameter and thickness of cookies increased. However, the spread ratio decreased. Adding of coconut flour significantly influenced on changes in diameter, thickness and spread ratio of cookies in baking. It could be explained by the establishment of structure of cookies due to dehydration of dough under high temperature in baking [16].

Table 5. Influence of coconut flour on properties of cookies.

<table>
<thead>
<tr>
<th>Percentage of coconut flour</th>
<th>Diameter (cm)</th>
<th>Thickness (cm)</th>
<th>Spread ratio (-)</th>
<th>Hardness (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4.44 ± 0.02a</td>
<td>0.67 ± 0.001d</td>
<td>6.59 ± 0.02a</td>
<td>624.97 ± 23.82a</td>
</tr>
<tr>
<td>15</td>
<td>4.29 ± 0.01b</td>
<td>0.64 ± 0.002b</td>
<td>6.75 ± 0.04a</td>
<td>787.73 ± 17.11bc</td>
</tr>
<tr>
<td>20</td>
<td>4.26 ± 0.01c</td>
<td>0.65 ± 0.001c</td>
<td>6.52 ± 0.07b</td>
<td>830.70 ± 15.51cd</td>
</tr>
<tr>
<td>25</td>
<td>4.23 ± 0.02d</td>
<td>0.66 ± 0.05d</td>
<td>6.41 ± 0.05c</td>
<td>870.57 ± 4.19de</td>
</tr>
<tr>
<td>30</td>
<td>4.21 ± 0.01de</td>
<td>0.66 ± 0.02d</td>
<td>6.40 ± 0.06c</td>
<td>1,014.67 ± 39.56f</td>
</tr>
<tr>
<td>35</td>
<td>4.20 ± 0.01e</td>
<td>0.66 ± 0.05d</td>
<td>6.32 ± 0.03c</td>
<td>1,159 ± 43.67f</td>
</tr>
</tbody>
</table>

The mean ± standard deviation within a column with different uppercase superscript letters was significantly different (p < 0.05).

(*) : Percentage of coconut flour in coconut – wheat mixture

4. CONCLUSIONS

The influence of particles sizes on hydration properties of coconut flour; including: water absorption, water retention and swelling capacities; and oil binding capacity was significant. Specifically, WAC and SC values were positively related to the particle sizes of coconut flour. In particle sizes from < 0.18 mm to 0.20–0.25 mm, WRC has the same correlation; however, in particle sizes from 20–25 mm to > 0.45 mm, it negatively related to particles sizes. Whereas, OBC
value decreased with increase in particle sizes of flour. Adding coconut flour into dough caused increase in adhesiveness, hardness and cohesiveness, but insignificantly affected on springiness. The result also indicated that adding coconut flour strongly influenced on texture of cookies in the way of decreasing spread ratio and increasing the hardness. These results can be applied for cookies production with substitution of coconut flour for wheat flour.

REFERENCES


TÓM TÁT

TÍNH CHẤT CHỨC NĂNG CỦA BỘT DỪA VÀ ÁNH HƯỞNG CỦA VIỆC BỘ SUNG BỘT DỪA ĐẾN TÍNH CHẤT CÂU TRỨC CỦA BỘT NHÀO VÀ BÁNH COOKIES

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Bột dừa, phụ phẩm từ quá trình sản xuất nước cốt dừa, có hàm lượng xơ và protein cao. Hiện nay, nó đang được quan tâm nghiên cứu sử dụng như nguyên liệu thay thế để sản xuất các sản phẩm bánh cookies. Nghiên cứu này khảo sát tính chất chức năng của bột phụ phẩm dừa và ảnh hưởng của việc bổ sung nó đến tính chất bánh nhào và bánh cookies. Kết quả thu được cho thấy, khả năng hút nước và khả năng tăng khi kích thước hạt của bột dừa phụ phẩm tăng. Giá trị cốt đai của khả năng giữ nước thu được với bột dừa có kích thước hạt từ 0,20–0,25 mm. Người lai, khả năng hút dầu lai giảm khi kích thước bột dừa tăng. Việc bổ sung bột phụ phẩm dừa vào bột nhào để thay thế một phần bột mì làm tăng độ cứng, độ cơ kết và độ dinh đặt; tuy nhiên, ảnh hưởng không đáng kể đến độ dán hồi của bột nhào. Sử bột sung đỏ cũng làm giảm tỉ lệ đường kinh/dò dày của bánh cookies trong quá trình nướng, đồng thời, làm tăng độ cứng của sản phẩm. Các kết quả thu được này có thể áp dụng để nghiên cứu tính khả thi của việc thay thế một phần bột mì bằng bột dừa phụ phẩm trong sản xuất các sản phẩm bánh cookies.

Tiếng khóa: bột dừa, bột nhào, tính chất chức năng, tính chất cấu trúc, bánh cookies.