Modification of Gluten-Free Starch and the Application on Cookies

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Abstract. Flour is a raw material widely used in the manufacture of food products, but the gluten content in flour can cause allergies, especially in people with Celiac Diseases. Therefore, it is needed to find alternative raw materials for flour. One way to replace flour is to use gluten-free starch and modify it to obtain specific characteristics. In this study, modifications were made to several starches, namely canna starch, cassava starch, and taro starch, by a cross-linking method using Sodium Tripolyphosphate (STPP) with various concentrations (0%; 0.5%; 1%; 1.5%). Each best characteristic was applied in the manufacture of cookies, and then a sensory test was carried out. The best analysis results were at a concentration of 1.5% STTP with the characteristics of canna starch is 80.15% starch content, 24.42% amylose, 16.077 swelling power, and 20.67% solubility. The characteristics of Cassava starch were 61.91% starch content, 23.85% amylose, 17.157 swelling power, and 24.37% solubility. The taro starch characteristics were 67.75% starch content, 23.88% amylose, 14.823 swelling power, and 21.97% solubility. The sensory test showed that most of the panelists like cookies made from taro starch-modified.

1. Introduction

As the primary raw material in the manufacture of biscuits, bread, cookies, and other foods, flour is widely consumed by modern society. The gluten content in this flour provides an advantage for flour because it functions to maintain the shape of the food, makes it elastic like rubber, and can withstand CO₂ gas from the yeast fermentation process to dough expands [1]. Apart from these advantages, it turns out that gluten also harms health, for example, allergies in people with Celiac Disease. At any age, Celiac disease can develop and produce a variety of manifestations [2]. Various kinds of symptoms arise due to celiac disease, both visible and invisible, such as weight loss from incorrect absorption of nutrients, diarrhea, anemia, and other diseases [3]. The presence of genetic, immunological factors, and pattern diet also affect celiac disease [4]. Therefore, it is needed to find alternative raw materials to replace wheat flour. From various literature, canna starch, cassava starch, and taro starch are starch types that do not contain gluten, so they can be used as alternatives flour but need to be modified to obtain specific characteristics.

Starch modification technology can be carried out genetically, enzymatically, physically, chemically, or a combination of both. Enzymatic modification of starch is carried out with enzymes while physically using several ways, including drying, extrusion, spray drying, heating, cooling, cooking, and other physical treatments. The starch modification process can also be carried out chemically by cross-linking, substitution, or a combination of both using chemicals as reaction assistants during the process [5]. Sodium Tripolyphosphate (STPP) is one of the cross-linked starch reactions [6]. Compared to other cross-linked reactions, STPP has the advantage of being easy to obtain, economical, and safe because it is a food-grade additive suitable for food production [7], it can
increase tenderness because it can bind and absorb water [8]. Phosphate groups in STPP can improve starch grains’ integrity because OH groups cross-linked with phosphate groups [9].

Flour is used to making cookies. Cookies are crunchy and made of soft dough with high fat [10]. Cookies' raw ingredients are flour with additives such as eggs, sugar, fat, and other ingredients cooked by roasting [11]. In this study, wheat flour was replaced with starch that has been modified with STTP. Therefore, a study was conducted to study the effect of STPP concentration on cannabis starch and cassava starch and its application in making cookies. The characteristics observed were starch content, amylose content, swelling, solubility, and sensory test on cookies.

2. Methodology
The research was conducted in 3 stages [12]:

a. Making canna starch, cassava starch, and taro starch;
b. Modification of canna starch, cassava starch, and taro starch with STPP according to treatment for 2 hours; and
c. Application best treatment on making cookies.

The research design used was a randomized block design (RBD) which involved 2 treatment factors with 3 replications. Treatment factors and each level are as follows:

The Factor I: Type of Starch (A)
A1 = Canna Starch; A2 = Cassava Starch; A3 = Taro Starch

Factor II: Concentration of STPP (B)
B0 = 0% (v / b); B1 = 0.5% (v / b); B2 = 1% (v / b); B3 = 1.5% (v / b)

3. Results and Discussion
3.1. Analysis of Starch Levels

| Treatment | Starch content (%) | Average | Range(p) | DMRT 0.05(p) | Duncan Grouping |
|-----------|--------------------|---------|----------|-------------|-----------------|
| A1B0      | 91.75              | -       | -        | a           |                 |
| A1B1      | 88.65              | 2       | 2.525    | b           |                 |
| A1B2      | 84.15              | 3       | 2.651    | c           |                 |
| A1B3      | 80.15              | 4       | 2.732    | d           |                 |
| A2B0      | 78.15              | 5       | 2.789    | d           |                 |
| A2B1      | 75.00              | 6       | 2.831    | e           |                 |
| A2B2      | 75.00              | 7       | 2.863    | e           |                 |
| A2B3      | 70.65              | 8       | 2.889    | f           |                 |
| A3B0      | 70.65              | 9       | 2.909    | f           |                 |
| A3B1      | 67.75              | 10      | 2.926    | g           |                 |
| A3B2      | 66.30              | 11      | 2.939    | g           |                 |
| A3B3      | 61.95              | 12      | 2.951    | h           |                 |

Note: Numbers followed by different letters in the same column means significantly different.

The data in table 1 shows that the modified starch content decreased with increasing STPP concentration. It happens because the phosphate bridges formed in the starch molecules are not detected as a substitute for the hydrogen bridges so, that the analyzed starch content decreases [13].
3.2. Analysis of Amylose Levels

| Treatment | Amylose Levels (%) Average | Range (p) | DMRT 0.05(p) | Duncan Grouping |
|-----------|---------------------------|-----------|--------------|----------------|
| A1B0      | 25.80                     | -         | -            | a              |
| A1B1      | 24.84                     | 2         | 0.06029      | b              |
| A1B2      | 24.58                     | 3         | 0.06329      | c              |
| A1B3      | 24.42                     | 4         | 0.06519      | d              |
| A2B0      | 24.19                     | 5         | 0.06652      | e              |
| A2B1      | 24.04                     | 6         | 0.06750      | f              |
| A2B2      | 24.03                     | 7         | 0.06825      | fg             |
| A2B3      | 23.98                     | 8         | 0.06883      | g              |
| A3B0      | 23.90                     | 9         | 0.06930      | h              |
| A3B1      | 23.89                     | 10        | 0.06967      | h              |
| A3B2      | 23.86                     | 11        | 0.06997      | h              |
| A3B3      | 23.85                     | 12        | 0.07021      | h              |

Note: Numbers followed by different letters in the same column means significantly different.

From Table 2, it can be seen that modified amylose levels tended to decrease even though some of them were not significantly different. This is because the phosphate group from STTP can easily replace the OH group in amylose, especially the OH group located on the atom C no 2 because of the amylose chain's straight and open [13].

3.3. Analysis of Swelling Power Levels

| Treatment | Swelling power (g/g) Average | Range(p) | DMRT 0.05(p) | Duncan Grouping |
|-----------|------------------------------|----------|--------------|----------------|
| A2B3      | 17.16                        | -        | -            | a              |
| A1B3      | 16.08                        | 2        | 0.08327      | b              |
| A1B3      | 14.84                        | 3        | 0.08743      | c              |
| A2B2      | 14.26                        | 4        | 0.09010      | d              |
| A1B2      | 14.03                        | 5        | 0.09197      | e              |
| A2B1      | 13.78                        | 6        | 0.09336      | f              |
| A1B2      | 13.69                        | 7        | 0.09442      | g              |
| A1B1      | 12.08                        | 8        | 0.09526      | h              |
| A2B0      | 11.69                        | 9        | 0.09594      | i              |
| A1B1      | 11.52                        | 10       | 0.09648      | j              |
| A1B0      | 10.27                        | 11       | 0.09693      | k              |
| A2B0      | 6.2                          | 12       | 0.09729      | l              |

Note: Numbers followed by different letters in the same column means significantly different.

This is due to the phosphate group resulting from cross-linking, which easily binds water because it is polar, increasing the swelling power when heating because water easily enters the starch granules [14]. The increasing the concentration of STTP added, the more the swelling power increases, because the more phosphate groups are formed, where the phosphate groups formed are hydrophilic (water-like ions) [15].
3.4. Analysis of Solubility Levels

Table 4. The effect of the interaction between the two treatments (A, B) on solubility

| Treatment | Solubility (%) | Average | Range (p) | DMRT 0.05 (p) | Duncan Grouping |
|-----------|----------------|---------|-----------|--------------|-----------------|
| A2B3      | 24.37          | -       | -         |              | a               |
| A2B2      | 22.63          | 2       | 0.948     | b            |                 |
| A2B3      | 21.97          | 3       | 0.995     | b            |                 |
| A1B3      | 20.67          | 4       | 1.026     | c            |                 |
| A1B2      | 18.87          | 5       | 1.047     | d            |                 |
| A1B2      | 14.90          | 6       | 1.063     | e            |                 |
| A1B1      | 13.93          | 7       | 1.075     | f            |                 |
| A1B1      | 13.37          | 8       | 1.084     | f            |                 |
| A1B1      | 13.10          | 9       | 1.092     | f            |                 |
| A1B0      | 11.20          | 10      | 1.098     | g            |                 |
| A2B0      | 10.33          | 11      | 1.103     | gh           |                 |
| A1B0      | 10.13          | 12      | 1.107     | h            |                 |

Note: Numbers followed by different letters in the same column means significantly different.

This is due to the formation of cross-links, which weaken the hydrogen bonds between starches so that water can easily enter the starch and form bonds between starch and water. The excess water content causes the starch granules to expand to be easily dissolved in water [16]. The more increased cross-links that occur, the more solubility.

3.5. Sensory Analysis of Cookies

To determine the level of consumer preference for a product, a hedonic test is necessary. In this study, panelists will assess the cookie product based on 3 parameters: taste, texture, and colour, with the preferred scale used 1-4 [17].

a) Taste

In a food product, the taste is one of the main factors affecting the level of people's liking for a product [18]. A product will not sell well in the market if the taste is less attractive to consumers even though it has good nutritional content.

![Figure 1. Hedonic test of the taste of cookies](image)

From Figure 1, it can be seen that the preferred cookies are cookies with modified starch raw materials with the highest concentration. One that affects the taste is the protein, in addition to other taste components [19]. In modified starch, the reduction in protein and amino acid levels is inhibited by the presence of cross-linking from STT [20].

b) Colour

The consumer's first impression of a product is colour. Before trying to consume food, people will assess the colour first. Because usually from the warrants, we can suggest the taste displayed. Apart from being influenced by the raw material for which it is made, colour is also influenced by chemical reactions that occur, such as browning or caramelization reactions [19].
Figure 2. Hedonic test of the colour cookies

The increase in preference from the A3B3 treatment (taro starch with the addition of 1.5% STPP concentration) was due to the more attractive color produced (fig 2). This is due to the melanoidin reaction, which is the reaction between sugar and amine groups, which produces a brown color on the cookies during heating [20].

c) Texture

The parameter that can be felt by the skin and the sense of taste is texture.

Figure 3. Hedonic test of the texture of cookies

The most preferred cookie texture by panelists was in the A3B3 treatment (taro starch with the addition of 1.5% STPP concentration). The texture of the cookies obtained is crisper and smoother because the starch and amylose content is less due to the cross-linking occurs so that the product is easier to break [21].

4. Conclusion

The best analysis results were at a concentration of 1.5% STTP with the characteristics of canna starch is 80.15% starch content, 24.42% amylose, 16.077 swelling power, and 20.67% solubility. Cassava starch characteristics were 61.91% starch content, 23.85% amylose, 17.157 swelling power, and 24.37% solubility. Taro starch characteristics were 67.75% starch content, 23.88% amylose, 14.823 swelling power, and 21.97% solubility. The sensory test showed that most panelists like cookies made from taro starch-modified 1.5% STTP.

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