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International Journal Of Modern Engineering Research (IJMER)

Improvement of Physicochemical and Functional Characteristics of Corn Starch Through Biological-Physical Modification

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ABSTRACT*:* This study aimed to improve the physicochemical and functional characteristics of corn starch using biological-physical methods (spontaneous fermentation and heating-cooling). The research method used to achieve this goal was spontaneous fermentation of local varieties of hybrid corn grains over a period of 36 hours, followed by the extraction of spontaneous fermented corn shells and modified corn starch with heating-cooling period varying from 15 to 30 minutes. Starch modified by fermentation and heating-cooling showed significantly different results than those without modified treatment. Modification of starch with 36 hours fermentation and 15 minutes of heating-cooling was able to improve the physicochemical and functional characteristics of starch with moisture content of 10,009%, amylose content 26,98%, Starch resistance 36,492%, gel strength 2,989 g/cm^2, swelling power 19,881 g/g and low solubility of 15,201%.

***KEYWORDS**: corn starch, physicochemical, heating-cooling, modified by fermentation*

Date of Submission: 28-12-2018 Date of acceptance: 11-01-2019

I. INTRODUCTION

In order to ensure food security in Indonesia, one of the plant sources of carbohydrates with a large potential for development is corn. Increasing production and quality of corn in the food sector must remain the government's top priority. The biggest potential of West Kalimantan corn resources is in Kubu Raya Regency, so there is an opportunity to develop diversified consumption of food from corn ingredients to meet the food needs of the community and the development of corn-based food industries in West Kalimantan in particular and Indonesia in general.

Processing corn into starch can increase its economic value. Starch is a glucose homopolymer with a-glycosidic bonds, commonly found in plants, especially in grains and tubers. Corn starch is one type of binder. Binders function to reduce shrinkage during cooking, brighten colors, increase product elasticity, compact texture and draw water from the dough[1]. Corn starch also functions as a filler. The filler can stabilize, concentrate or thicken the food mixed with water to a certain level of thickness.

Natural corn starch with low amylose content needs to be processed using modifying technology. Starch modification is an attempt to improve the physicochemical and functional properties of starch. One modification that can be done is spontaneous fermentation and heating-cooling which are relatively safe and simple to do. The application of spontaneous fermentation methods and heating and cooling of corn starch can increase resistant starch levels[2]. Thus, technological innovations in the use of local resources (corn) increase the economic value and social value of corn in the community, produce food products that have physicochemical and functional characteristics in accordance with the wishes and needs of the community and provide healthbenefits.

II. METHODS

2.1. Spontaneous Fermentation of Corn granules

Local varieties of corn flour are spontaneous fermentation with soaking water: ingredients (2: 3) with 36 hours fermentation time. Every 12 hours the marinated water is removed and replaced with clean water with the same ratio.

2.2. Extraction process of corn starch

Corn starch was extracted using extraction modification method with the following steps: spontaneously fermented shelled corn was crushed using a blender with the addition of water (1: 1)[3]. Next is filtering. The pulp is obtained, plus the water is filtered again to obtain a clear white filtrate. Water and sediment are then separated. Wet starch is then dried using a drying oven for 1 night at 50ºC, until dry starch is obtained. Dry starch is sieved 80 mesh and starch obtained is stored in a tightly closed container. The dried starch is then milled and sifted using an 80 mesh size sieve. The starch obtained is stored in a tightly closed container.

2.3. Modification of corn starch with a heating-cooling process

Modification of corn starch using a the heating-cooling process[4,5]. In principle, the starch water content is conditioned until the water content becomes 25%. Then packed with HDPE plastic and stored in the refrigerator (temperature 5^0C, for 12 hours). Next the starch is heated by autoclaving for 15 minutes and 30 minutes at 121^{o}C. After that it is cooled for 1 hour at room temperature, then reconstructed through cooling for 24 hours at 4^{o}C. The starch is then dried using an oven (temperature 60^{o}C) for 16 hours and smoothed and sifted with an 80 mesh sieve.

Water content regulation is done by adding aquades until it reaches 25% ± 1 moisture content by manually spraying and stirring aimed at uniforming the water content in the Autoclaving-cooling process. The amount of aquades added is calculated using the principle of mass equilibrium. The mass equilibrium formula that can be used is as follows:

(100% - KA1) x BP1 = (100% - KA2) x BP2

Information: KA1 = moisture content at initial conditions (% bb)
KA2 = desired moisture content (% bb)
BP1 = initial starch weight
BP2 = starch weight after reaching KA2

III. RESULTS AND DISCUSSION

In this study, shelled corn with local varieties was provided without spontaneous fermentation and spontaneous fermentation for 36 hours, followed by starch extraction process. The yield of local corn starch is 35,556% and 35,567%. Furthermore, corn starch was modified through a heating and cooling process for 15 minutes and 30 minutes. The results of the analysis of physicochemical and functional characteristics of corn starch through biologically modified are shown in Table 1.

Table 1. The results of the analysis of physicochemical and functional characteristics of corn starch

Composition	Without Spontaneous Fermentation (TF)			Spontaneous Fermentation (F36)		
	TPP	PP 15	PP 30	TPP	PP 15	PP 30
Rendemen (%)	35,556 ^{a}	35,598 ^{a}	35,577 ^{a}	35,564 ^{a}	35,526 ^{a}	35,600 ^{a}
Moisture content (%)	9,127^d	9,606^c	9,998^b	9,709^c	10,009 ^{a}	10,209 ^{a}
Amylose content (%)	19,188^d	23,691^{cd}	24,090^c	22,662^b	26,984 ^{a}	26,966 ^{a}
Resistant starch content (%)	13,466 ^{f}	20,872 ^{e}	24,332 ^{cd}	23,256 ^{d}	36,492 ^{b}	38,273 ^{a}
Solubility (%)	18,289 ^{a}	16,921 ^{b}	16,812 ^{b}	16,886 ^{b}	15,201 ^{d}	16,381 ^{c}
Swelling Power (g/g)	16,738 ^{e}	17,899 ^{c}	17,885 ^{c}	17,284 ^{d}	19,881 ^{a}	19,620 ^{b}
Gel strength (g/cm^2)	2,711 ^{c}	2,888 ^{b}	2,870 ^{b}	2,868 ^{b}	2,989 ^{a}	2,911 ^{ab}

TPP = without heating-cooling; TPP 15 = heating-cooling until 15 min; TPP 30 = heating-cooling until 30 min

3.1. Moisture content analysis of modified corn starch

Based on the results of statistical calculations, the water content of modified corn starch showed significantly different results. The water content of modified corn starch has increased, from 9,127% to 10,399%. The fermentation process tends to cause an increase in the absorption capacity of modified corn flour water[6]. Corn that develops because it absorbs water during immersion makes it easier to absorb water because the complex molecules would break into simpler ones.The longer the corn starch is heating-cooling, the greater the ability of starch to bind water. Besides that, the water content in food is strongly related to the shelf life of these foods[7]. The shelf life of starch with a moisture content below 14% is one year. The water content of modified corn starch is below 14% so it is hoped that it can be stored longer because of the low water content making it difficult for destructive microbes to survive.

3.2. **Amylose content analysis of modified corn starch**

Amylose content plays an important role in identifying the robustness of the structure of corn starch. Amylose is a straight polymer glucose chain that contributes to the formation of a heated and cooled starch gel system. Modified corn starch without spontaneous fermentation and spontaneous fermentation, followed by heating-cooling, showed a higher amylose content of 19,188%-26,984%. This means that the starch modification process can break the amylopectin branching bonds into amylose straight bonds. Furthermore, amylose will undergo retrogradation after being pressurized heated-cooled. The longer the starch warms, the amylose content decreases. This shows the limitation of the amylopectin fraction in breaking its branching bonds. Amylose content of corn starch modified that shown in Figure 2.

3.3. **Resistant Starch (RS) content analysis of modified corn starch**

The resistant starch produced from the retrogradation process is type III resistant starch (RS3). Retrogradation can produce modified starch with strong bonds. The modified corn starch can increase the level of RS from 13,4669% - 38,273%. The longer the heating-cooling time, the more modified modified corn starch hospitals are. Amylose will undergo retrogradation after the heating-cooling treatment. Methylated amylose plays a role in increasing levels of RS[8]. Amylose crystallization occurs through the extension of the double helix formation chain between amylose molecules that are close to the end of the chain. Amylose crystallization also occurs due to chain folding. Extension of the amylose chain fold facilitates helical mergers through interhelical arrangement of hydrogen bonds[9].

3.4. **Solubility analysis of modified corn starch**

The interaction of modification of spontaneous fermentation and the heating-cooling process of corn starch will have a significant effect on the level of solubility. The data in table 1 and graph 4 show that corn fermentation without fermentation and without cooling heating has a high solubility - 18,289%. Biological-physical starch modification process can reduce starch solubility. Starch with 36 hours fermentation modification and 15 minutes heating-cooling had a low solubility of 15,201% but by heating for 30 minutes the solubility increased to 16,381%. Changes in the solubility of modified corn starch were caused by changes in the structure of weakened crystalline starch in starch granules. Low molecular weight amylose has short straight chains,rendering it more soluble in water[10].

3.5. **Swelling Power analysis of modified corn starch**

The fermentation and heating-cooling time has significant effect on the swellingpower of corn starch. Swellingpower of corn starch without fermentation and continued with heating and cooling treatmentbore different results, namely 16,738-7,885 g/g and 17,284-19,881 g/g. Corn expandd during immersion and easily absorbed water because the complex molecules broke into simpler ones. However, the longer the corn starch undergoes heating-cooling, the lower theability of starch to bind water is and the more limited the swelling power becomes. Low swelling power of starch is related to the limitation of water penetration into starch due to increased starch crystallinity after it’s been modified[11].

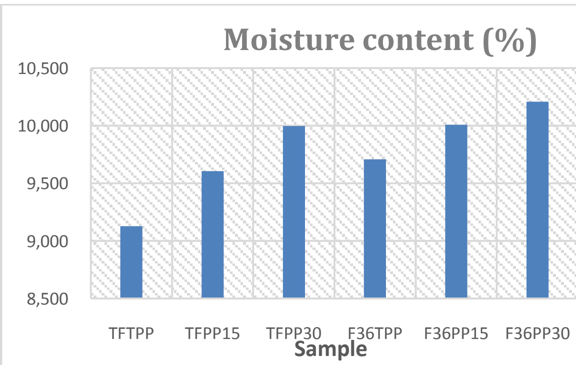

Figure 1. Moisture content of starch modified chart

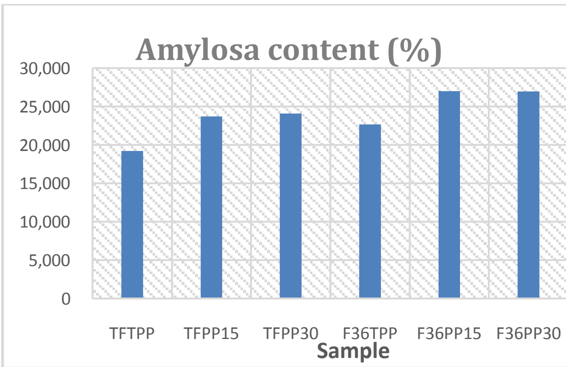

Figure 2. Amylosa content of starch modified chart

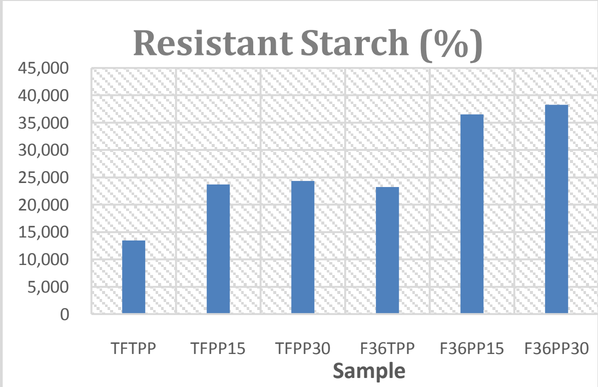

Figure 3. Resistant Starch of starch modified Chart

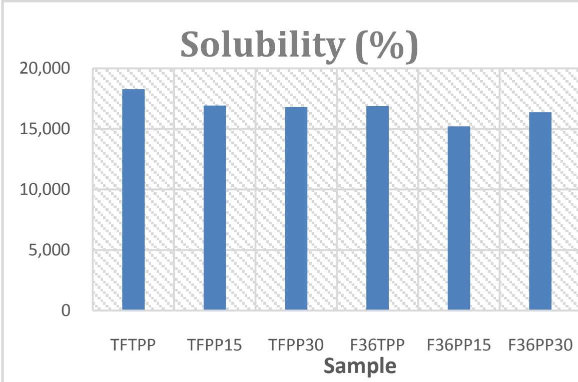

Figure 4. Solubility of starch modified chart

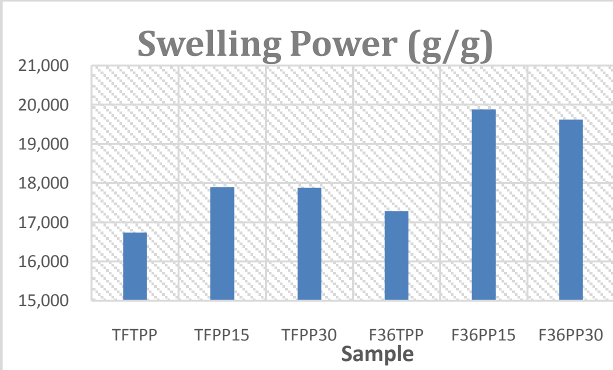

Figure 5. Swelling Power of Starch Modified Chat

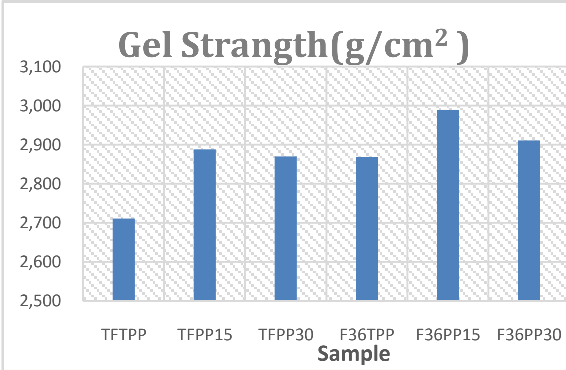

Figure 6. Gel Strangth of starch modified Chat

3.6. Gel strength analysis of modified corn starch

The results of the observations on the strength of the gel of corn starch after undergoing several treatments showed significantly different results and can be seen in Table 1 and Figure 6. The gel strength of the modified starch was higher than the strength of the unmodified starch gel. After modification, there was an increase in the strength of gel starch caused by the addition of intermolecular bonds of amylose starch granules. But with a long heating time comes reduced robustness and strength of the starch gel. The damage to the structure of starch granules causes amylose to come out, thereby reducing viscosity or gel strength. Rupture of starch granules that have undergone modifications can affect their ability to form gels[12].

IV. CONCLUSION

The conclusions of this study are based on the results of the study it was found that modification of starch with 36 hours fermentation and 15 minutes of heating-cooling was able to improve the physicochemical and functional characteristics of starch with moisture content of 10,009%, amylose content 26,98%, Starch resistance 36,492%, gel strength 2,989 g/cm^2, swelling power 19,881 g/g and low solubility of 15,201%.

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Lamria Mangunsong" Improvement of Physicochemical and Functional Characteristics of Corn Starch Through Biological-Physical Modification" International Journal of Modern Engineering Research (IJMER), vol. 08, no. 11, 2018, pp 24-28