Utilization of modified starch from avocado (*Persea americana* Mill.) seed in cream soup production

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Abstract. Avocado (*Persea americana* Mill.) seed was often seen as waste and underutilized resources, especially in the food industry. The aim of this research was to modify the structure of avocado seed starch using the cross-linking method, to improve the viscosity stability in the cream soup. In the preliminary research, starch was isolated from the seed and modified by STPP (sodium tripolyphosphate) with 2%, 4%, and 6% concentration and were reacted for 1, 2, and 3 hours. Starches were analyzed for moisture and ash content, paste clarity, gel strength, swelling power, solubility, yield, and degree of whiteness. Based on the analysis results, the best reaction time and STPP concentration was 6% at 1 hour reaction time. Native starch and the best-modified starch were applied in the cream soup and compared with commercial cream soup. Cream soups were analyzed for viscosity stability using viscometer in 0, 1, 3, and 5 hours after storage in room temperature. The result showed that cream soup using modified starch has better viscosity stability than native starch and commercial cream soup after 5 hours storage, which was 181.7 ± 4.85 cP. Sensory analysis showed that cream soup using modified starch was more acceptable than the others. Avocado seed modified starch has phosphate group that strengthen the starch chain to prevent viscosity breakdown.

Keywords: *avocado seed, cream soup, cross-linking, modified starch, viscosity stability*

1. Introduction

Consumption of avocado (*Persea americana* Mill) had increased worldwide in recent years. Avocado seed as a part of avocado fruit (25% w/w) were seen as waste and underutilized resources, especially in the food industry. Currently, the seed represents waste issue lead to environmental pollution. The way to overcome that waste problem was by processing of avocado seeds starch. Avocado seeds contain about 30% starch, so this starch has the potential to be further processed [1]. Starch could be categorized as native (natural) starch and modified starch. Natural starch could be obtained by extraction for example from seeds. Natural starch was limited usage in food industry because of stickiness, and intolerance of the acid treatment. Starch modification has been widely used to improve the functional properties of food products. Some method was used to be modified starch, i.e. chemically, physically, and enzymatically [2]. Each method will enhance the functional properties of the food product such as increasing the water binding capacity, increasing the resistance to the heating temperature, minimizing the occurrence of retrogadation or sineresis, and improving and maintaining viscosity despite stirring, etc. [3]. Modification of starch by cross linking method was one of chemical

modification by cross-linking -OH within amylose or amylopectin structure, so it could form crosslink or bridge connecting one starch molecule with other starch [4]. Cream soup was a slightly different product with many soup in general, because of the texture was more viscous. The cream soup was a product that usually made from wheat flour, potato starch, or corn starch [5]. High viscosity was produced by the starch in flour, milk or cream. The problem in cream soup was the viscosity of the cream will decrease during storage, resulting the texture of the cream soup becomes more fluid. Therefore, by this research avocado seed waste was utilized by cross-linking modification of avocado seed starch, hopefully the viscosity of the cream soup was stable even it was stored at room temperature for such a long time.

2. Research Method

2.1. *Materials and equipment*

Materials used in this research were avocado seeds as main raw material and ingredients for making cream soup such as full cream milk, modified avocado starch, natural avocado starch, iodized salt, white pepper powder, garlic powder, butter, sugar and water. Chemicals were used are Sodium Tri Poly Phosphate (STPP), NaOH, and HCl.

Equipment used in this research were analytical balance, blenders, pH meters, sieve shaker, water bath, Brookfield viscometer, Minolta Chromameter CR-400, Rapid Visco Analyzer, Scanning Electron Microscope, and Fourier Transform Infra Red (FTIR).

2.2. *Methods*

2.2.1. *Research phase I.* The extraction of avocado seeds to get the natural starch using water as solvents. Avocado seed were blended with water and filtered by filter cloth. Before blending, avocado seeds were given soaking treatment using 3000 ppm sodium metabisulfite for 24 hours to prevent the browning reaction [6], [7]. The precipitated was centrifuged 3500 rpm for 10 min and dried for 24 hours at 50 °C.

The natural starch was then modified by crosslinking method with addition of 2%, 4% and 6% STPP and reacted for 1 hour, 2 hours and 3 hours. The experimental design was a Completely Randomized Design (CRD) with two factors, that were STPP concentration (2%, 4%, and 6%) and reaction time (1 hour, 2 hours, and 3 hours), with three repetitions. The process of modification were begun by mixing 50 gr of starch with 125 mL of distilled water. Furthermore, STPP was added according to the treatment and pH adjusted to 10.5 with 5% NaOH added. This solution was reacted at 45°C in a water-bath. The solution will have a pH setting back up to 5.5 with the addition of 0.1% HCl. The final solution will be centrifuged 3500 rpm for 15 minutes and the precipitate was dried for 24 hours at 50°C.

2.2.2. *Research phase II.* Application of the best natural starch and modification starch from research phase I in making cream soup. Preparing the cream soup by making chicken broth by boiling chicken in water with a ratio of 1: 2 at 90°C for 60 minutes. The ingredients used were weighed according to the formulation. The cooking process is begun by mixing the butter with the starch used. After flattening, chicken broth and full cream milk are added and cooked at 86-90°C until homogeneous. The last stage was addition of salt, white pepper powder, sugar and stirring until the cream soup thickened.The formulation of making cream soup could be seen in Table 1.

The experimental design was Completely Randomized Design (CRD) of two factors, the first factor (3 levels) were type of starch (natural avocado starch, modified avocado starch, and commercial cream soup), and the second factors (4 levels) were storage time (0 hour, 1 hour, 3 hours and 5 hours) with each three repetitions.

Table 1. Formulation of cream soup production.

Material	Composition
Chicken Broth	500 (mL)
Full cream milk	250 (mL)
Natural or Modification Starch	25 (g)
Butter	30 (g)
Sugar	8.46 (g)
Salt	4 (g)
White pepper powder	0.45 (g)

3. Results and Discussion

3.1 E*ffect of % STPP addition and reaction time toward yield, moisture and ash content of modified avocado seeds starch*

The statistical test resultshowed that % STPP addition and reaction time had significant effect and interaction ($p<0.05$) on the % yield of modification starch. One hour reaction time will result the highest yield when the %STPP was increased. The longer reaction time, the yield of starch decreased. It could be caused by longer contact of starch with hot temperature will cause the components lifted during heating and drying, thus lowering yield of modification starch.The statistical test resultof water content showed that %STPP and reaction time did not give any significant effect ($p>0.05$) and no interaction. Although the addition of phosphates in different concentrations, but the same drying process so that the number of water molecules that came out of the material was not different [8].The statistical test result on ash content showed that the % STPP and reaction time had significant effect and interaction ($p<0.05$). The more bound phosphate groups, the more ash content produced because the phosphate was the ash component [9]. The longer the phosphate reacts with starch, the more time the phosphate group has to penetrate into the starch granules.

3.2 E*ffect of %STPP addition and reaction time toward paste clarity, gel strength, swelling power, solubility, degree of whiteof modified avocado seeds starch*

The statistical test result on paste clarity, gel strength, swelling power, solubility and degree of white of starch showed that the addition of%STPPand reaction time had significant effect and interaction ($p<0.05$). The addition of %STPP as a cross-linking reagent will decrease the paste clarity value. The presence of phosphate compounds as cross-linking reagents will alter the structure of the starch granules as the modified starch will break the structure when heated to 95°C and decrease the paste clarity [10]. The higher %STPP added, the higher the gel strength produced. Increasing of %STPP will increase hardness and gel strength because of the higher concentration used, the stronger also the starch chains are produced. The formed gels will become more rigid and the bonds that occur between the polymers that make up the gel are stronger. The higher % of STPP added, the more decreasing the swelling power. This result was accordanceto[11]that crosslinked starch will decrease swelling power value compared to natural starch, because the modified starch granules with crosslinks will be stronger and make the starch more resistant to acid and heat medium so it is not easy to experience viscosity breakdown when done heating. Cross-modified starch will strengthen the bond between the starch chains thus retaining the starch granules for swelling. The higher %STPP added, the smaller the solubility of the starch produced. This result was according to [10]that the decreased solubility value due to crosslink modification was due to the increased density of the modified starch structure, which reduces the disintegration of starch granules. This decreased solubility value indicates a stronger starch bond than natural starch. The higher of %STPP added and the reaction time taken, the degree of white also decreased. Starch composed by amylose and amylopectin will be broken down into simple sugars. The sugars formed will produce a maillard reaction. This was because starch still has protein content

that could react with simple sugars in starch causing the decrease of white degree of crosslinked starch modification [12].

3.3 *Determination of the best avocado seed modification starch*

The best choice of modification crosslinking method (STPP 6%, 1 hour reaction time) could be seen in Table 2. Based on the analysis of physical and chemical characteristics of avocado modified starch, the addition of 6% STPP with 1 hour reaction time were determined as the best crosslinking starch modification. The reaction time was determined based on best results and best effectiveness. Determination of this best results based on the value of swelling power, solubility, paste clarity, and gel strength were the best. The best crosslinked avocado seeds were analyzed for starch, amylose, amylopectin, starch gelatinization profile, starch structure, and the shape and size of starch granules.

Tabel 2. Results of analysis of natural avocado seedstarch and the best of modified avocado seedstarch.

	Analysis Result	
Parameter	Natural Starch	Modified Starch
Water (%bb)	11.33 ± 0.06	11.67 ± 0.36
Yield (%)	8.05 ± 0.27	78.79 ± 1.16
Ash(%)	0.07 ± 0.00	0.13 ± 0.00
Paste Clarity (%T_{650})	1.17 ± 0.00	0.56 ± 0.02
Gelatinization Temp (^{0}C)	83.25	80.90
Peak Viscosity (cP)	3330	4890
SetbackViscosity (cP)	2021	1709
Heat Viscosity (cP)	2900	4943
Gel Strength (g)	67.7 ± 0.44	109.73 ± 2.93
Swelling Power (g/g)	6.32 ± 0.10	4.12 ± 0.06
Solubility (%)	12.57 ± 0.06	3.00 ± 0.13
White Degree (%)	86.81 ± 0.90	69.23 ± 1.62
Starch (%)	91.48 ± 0.06	87.62 ± 0.31
Amylose (%)	42.37 ± 0.14	39.17 ± 0.07
Amylopectin (%)	49.11	48.45

3.4 *Structure of starch analysis by Fourier Transform Infra-Red (FTIR) Spectroscopy*

The natural avocado seed starch's were showed in wavelength of 1014.9357 cm^{-1}. The modified avocado seed starch's wavelength 1012.1641 cm^{-1}. The FTIR analysis showed that there are P = O groups shown at wavelengths of 1150.7464 cm^{-1} for modified avocado seed starch and 1156.287 cm^{-1} for natural avocado starch. The structure of natural and modification of avocado seed starch showed that it was not much different. This could be caused the crosslinking reactions in the starch chain did not interfere and change the structure of starch [13].Result analysis of natural and modified starch by FTIR Spectroscopy could be seen in Figure1 and Figure2.

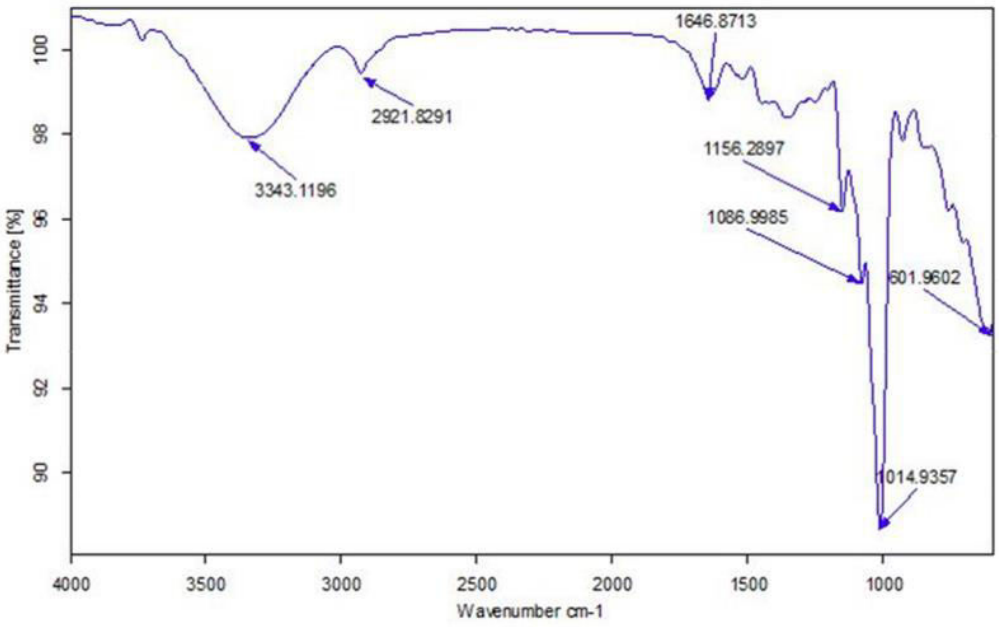

Figure1. Natural starch from avocado seed.

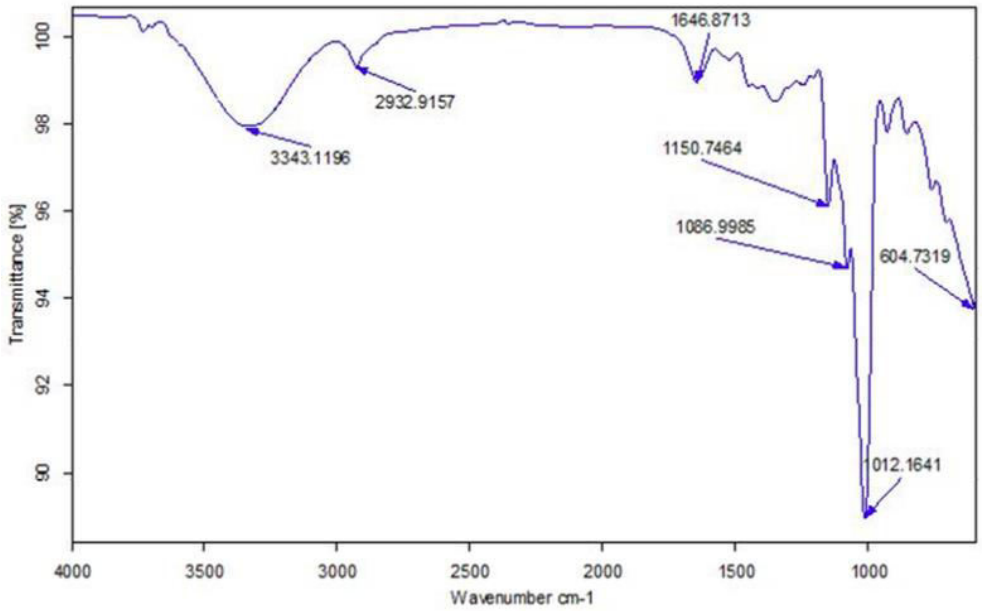

Figure2. Modified starch from avocado seed by crosslinking method.

3.5 *Starch, amylose and amylopectin content of modified avocado seed starch*

The starch content from the best modified starch was 87.62%, lower than natural avocado seed starch (91.48%). The decrease of % starch was caused by % STPP added while phosphate compound caused increasing non-starch components such as cellulose, hemicellulose, pectin and lignin. These components caused decreasing in starch content [14]. Amylose and amylopectin of modified avocado starch also decreased from natural avocado seed starch, for amylose 42.37% to 39.17% and amylopectin 48.45% from 49.11%.

3.6 *Shape and size of starch granules by Scanning Electron Microscope (SEM)*
The natural avocado starch has size between 8.82 µm to 22.94 µm with ovoid shape, oblong elliptical and circle as in Figure3. While shape and size of modified avocado starch (6%, 1 hour) as in Figure 4 showed between 5 µm to 20 µm with ovoid shape, oblong elliptical and circle. These results indicate that crosslinked starches were smaller in size than natural starches and there was no difference in shape between natural starch and modified starch. According to [15], the crosslinked starch modification has a similar shape to natural starch but has a smoother surface and did not have many pores compared to natural starch.

3.7 *The gelatinization temperature*
The gelatinization temperature of natural avocado starch was 83.25^{0}C while the modified avocado seed starch decreased to 80.90^{0}C. The decreasing may be caused by weakening of the granular structure and disintegration during the modification process [16].

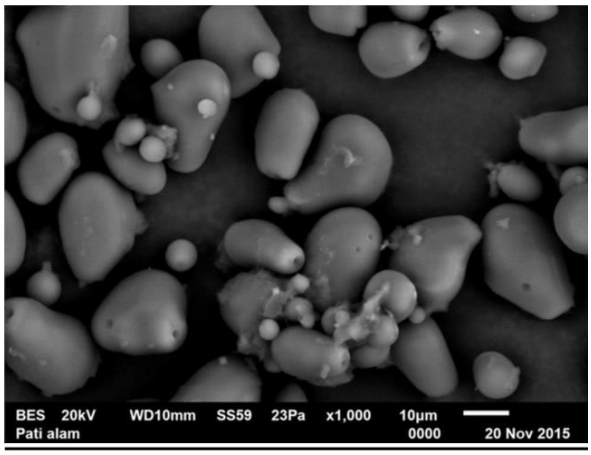

Figure 3. Natural Avocado Seed Starch with 1000x magnification (analyzed by PT. Nanotech Herbal Indonesia).

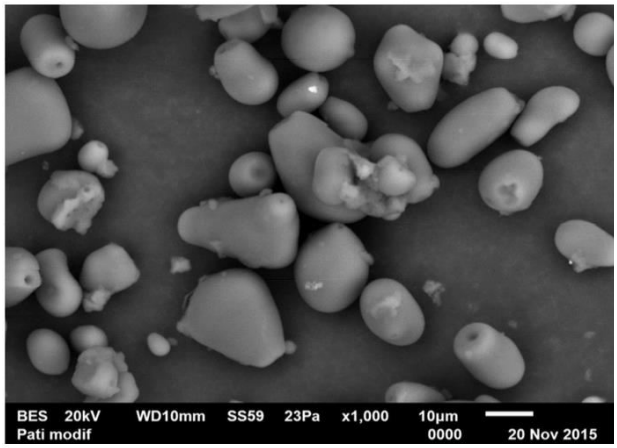

Figure 4. Modified Avocado Seed Starchwith 1000x magnification (analyzed by PT. Nanotech Herbal Indonesia).

3.8 *Peak viscosity*
The best peak viscosity of avocado seed starch yields was 4840 cP. This result according to other research result that cross-link modification process tends to increase the peak viscosity value, but only in a certain concentration of% STPP increased, the peak viscosity value will have decreased. Increased viscosity may occur due to crosslinking of amylopectin and amylose molecules so that the integrity of starch granules is stronger. Therefore, when heated, the starch hydration capacity of the starch granules is greater, and the peak viscosity increases [17].

3.9 *Heat viscosity*
Heat viscosity was a parameter used to determine the ability of starch granules in self-defense or viscosity during heating. The heating process was usually carried out at 95 °C for 20 minutes. The results of heat viscosity analysis on natural avocado seed starch and modification were 2900 cP and 4943 cP, respectively. Increasing of this heat viscosity in modified starch accordance with the theory that the higher the concentration of STPP used, and the higher the heat viscosity value and was expected in soup products because the higher the value of heat viscosity, the starch granules can more and more self-defense during the heating process. The resulting cream soup product will have a more stable viscosity compared to natural avocado seed.

3.10 *Effect of starch type and storage time on modified starch viscosity stability*
The results showed that there was a decreasing in viscosity when soup was stored longer. The decrease in viscosity occurring in natural starch could be due to the nature of the starch that was not resistant to heating and stirring so that the viscosity decreases when stored caused by the bond between starch and protein causing the decrease of viscosity [16].

3.11 Effect of type of starch toward consumer acceptance in cream soup
The scoring and hedonic tests were performed on 70 untrained panelists with 1-7 scale. For example, scale 1-7: very tasteless creamy – very creamy feel. Based on the overall hedonic test results of the cream soup products, both products were acceptable to consumers. But the overall cream soup used modification starch was preferred score 5.29 which means rather like compared to natural starch soup. Based on all sensory test parameters color, flavor, taste, aftertaste, and viscosity, consumers prefer more like the cream soup used modified starch compared to natural starch. Both types of cream soup are acceptable to the consumer, but the viscosity of the cream soup with modified starch was preferred. The viscosity affects the consumer's preference that a thicker cream soup was preferred in this research.

3.12 *Proximate analysis of selected soup cream*
The selected cream soup was a cream soup which used modified starch of avocado seed, because this cream soup had a better stability of viscosity. The proximate analysis of the selected cream soup could be seen in Table 3.

Table 3. Proximate analysis of cream soup modified avocado seed starch.

Analysis	Result (%)
Water	86.76 ± 0.23
Ash	0.97 ± 0.00
Protein	2.45 ± 0.11
Fat	1.99 ± 0.01
Carbohydrate	7.83

4. Conclusion
Extraction yield of natural starch from the avocado seed was 8.05% wet basis. The more adding of % STPP and time of reaction, ash content and gel strength increased but the paste clarity, swelling power, solubility, and white grades color decreased. The best crosslinked avocado seed starch was obtained by adding6% STPP and one hour reaction time. The modified avocado seed starch had a lower amylose content than it's natural starch. The crosslinking modification process did not affect the shape and size of the avocado starch granules by SEM analysis. In making cream soup, the modified avocado seed starch gave more stable viscosity compared to natural avocado seed starch and commercial cream soup during storage time.

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