Application of heat-moisture treatment potato starch to improve the heat stability of tomato sauce

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Abstract. Modification through heat-moisture treatment (HMT) can improve the heat stability of starch. The objective of this research was to determine the effect of the addition of HMT-potato starch on stability and sensorial properties of tomato sauce. The research consisted of 4 treatments with the addition of HMT potato starch (0.5, 1, 1.5, and 2%) to tomato sauce which heated at 121 °C for 1 h. The result showed that tomato sauce had higher stability when added by HMT potato starch compared to the native potato starch. Addition of HMT potato starch of 1.5% resulted in tomato sauce which had the best characteristics, only decreased viscosity from 4563.33 cP to 3053.33 cP or 33.09% compared to the native potato starch (from 4773.33 cP to 1876.67 cP or 60.68%). Tomato sauce had a preference for viscosity, color, taste, flavor, and overall acceptability of 3.1, 3.2, 3.3, 2.9, and 3.3 respectively (rather liked). Based on the heat stability of tomato sauce, HMT-potato starch was suitable for the sterilization products.

1. Introduction
Potatoes especially var. Granola has various advantages including its large productivity (28 tons/ha) so that it has the potential to be used as a source of starch to support a variety of food industries, especially as thickening materials [1,2]. However, the use of native potato starch is limited because of problems related to retrogradation, syneresis, and low pasta stability to pH and temperature changes [3,4].

On the other hand, some foodstuffs, especially canned foods, require thickening agents that are stable to heat because canned foods are generally sterilized using high temperatures. Potato starch has the potential to be used as a thickener in tomato sauce for canned foods such as sardine and mackerel, but modifications to potato starch are needed to be more resistant to heating. One modification of starch that can improve the stability of pasta was heat-moisture treatment (HMT) [5,6]. The starch that was modified by HMT had higher freeze-thaw stability than native starch and lower breakdown viscosity which indicated its stability during heating [7,8].

The characteristics and stability of tomato sauce can be affected by the amount of thickener or starch added [9,10]. Therefore the effect of the addition of HMT potato starch on the physical and sensorial properties of tomato sauce before and after sterilization was studied. The addition of HMT potato starch was expected to increase the stability and sensory quality of tomato sauce. Stable tomato sauce can provide better quality food.
2. Materials and methods

2.1. Materials
The materials used in this study were potato starch (*Solanum tuberosum* Linn, var. Granola) and tomatoes obtained from the area around Bandung, West Java. Supporting materials include salt, sugar, garlic, and vinegar.

2.2. Modification of potato starch by heat-moisture treatment (HMT)
The HMT modification procedure according to Collado *et al* [11] with some modification. Potato starch was conditioned on the moisture content of about 27%. Potato starch was wrapped in aluminum foil and placed in a container and then cooled in a refrigerator at 10 °C for 12 h to balance the water content. Potato starch was then heated at 110 °C for 16 h for the process of modification by the method of heat-moisture treatment (HMT) using an oven cabinet. The starch was then dried at 50 °C for 4 h until the water content was 12 ± 2%. The starch was then ground to reduce the size and sieved at 100 mesh.

2.3. Application of HMT potato starch on tomato sauce
Fresh tomatoes were washed with clean water, then blanched at 90 °C until soft and the skin was easy to peel. Tomatoes were peeled and then ground and filtered to get the filtrate. Tomato filtrate added seasonings include salt, garlic, sugar, and vinegar. HMT potato starch was then added at various concentrations of 0.5, 1, 1.5, and 2%. Tomato filtrate was concentrated by heating until tomato sauce was obtained with a total of dissolved solids of 35 °brix. The tomato sauce was packaged and tested for heat stability by heating at 121 °C for 1 h using an autoclave. Tomato sauce was then tested for its stability and sensorial properties before and after heating.

2.4. Determination of pasting properties
Determination of pasting properties using Rapid Visco Analyzer (RVA-SM2, Warriewood Australia) according to Koksel *et al* [12]. The potato starch sample was weighed 2.8 g on an aluminum canister then added with 25 mL of aquadest. The sample canister was inserted into the RVA then heated and cooled with constant stirring. The heating was set to a temperature of 50 °C held for 1 min, continued to 95 °C at 6 °C/min, then maintained for 5 min. Cooling the sample to a temperature of 50 °C at 6 °C/min, then maintained for 5 min.

2.5. Sensory evaluation
The 5-point hedonic scale method (1 very dislike, 5 very like) was used to evaluate sensorial properties. The panelists evaluate the sensory attributes which include thickness, color, taste, flavor and overall acceptance of tomato sauce before and after sterilization. Fifteen panelists were selected and then given directions to evaluate sensory attributes. Five formulations of tomato sauce with the addition of HMT potato starch (each weighing ~ 10 g) were served in a cup at a temperature of 25 ± 1 °C. Each sample was coded using three random numbers. Panelists were then asked to provide a sensory value for each tomato sauce sample. After each sample, one panelist was asked to drink water to rinse the palate so that the neutral mouth condition returned.

3. Results and discussion

3.1. Pasting properties
Characterization of pasting properties was needed for several purposes including identification of changes in viscoamylograph response due to differences in material or process variables, estimation of starch and flour properties during processing, and identification of initial data for the purposes of setting up starch and flour processing equipment. Modified starch can change the pasting properties of
starch or flour. The effect of HMT modification on the pasting properties of potato starch can be seen in figure 1.

Figure 1. Pasting properties (RVA viscoamylograph) of potato starch before and after modification by heat-moisture treatment (HMT).

HMT potato starch had significantly different pasting properties compared to native potato starch. HMT-potato starch had a higher pasting point (81.17 °C) than native starch (62.26 °C), while the breakdown viscosity of HMT potato starch was lower than native starch, 50 cP and 3261 cP, respectively (figure 1). Similar results were obtained by Suriya et al [13] that elephant foot yam starch obtained through HMT modification had higher pasting points and lower breakdown viscosity than native starch. This showed that HMT potato starch had resistance to starch gelatinization and was more resistant to heat or high temperatures. The higher pasting point of HMT-potato starch was due to the increased interaction between amylose molecules in the amorphous region and the interaction between amylose-amylopectin in the intercrystalline region. These interactions caused a decrease in the swelling of granules which were resistant to destabilization. The re-formation of the structure in starch granules was also caused the increase in pasting point [14]. The increased of crystalline matrix regularity and the formation of amylose-fat or amylose-protein complexes also reduced the swelling capacity of granules and improved paste stability during heating. HMT-potato starch was then used as a thickener on tomato sauce which was expected to have good heating stability.

3.2. The effect of HMT potato starch on viscosity tomato sauce
HMT potato starch was added to the tomato sauce then heated using an autoclave and evaluated its viscosity stability compared to the native potato starch. The effect of the addition of HMT potato starch on the viscosity stability of tomato sauce can be seen in table 1.
Table 1. The addition of HMT potato starch on the viscosity of tomato sauce (cP) before and after sterilization.

| Addition of starch | Before heating | After heating | % Decreased |
|--------------------|----------------|---------------|-------------|
|                    | Native potato starch | HMT-potato starch | Native potato starch | HMT-potato starch | Native potato starch | HMT-potato starch |
| 0.5%               | 3273.33         | 3247.33       | 580.00      | 1026.67       | 82.28           | 68.42           |
| 1%                 | 4170.00         | 4160.00       | 1426.67     | 2526.33       | 65.79           | 39.29           |
| 1.5%               | 4773.33         | 4563.33       | 1876.67     | 3053.33       | 60.68           | 32.84           |
| 2%                 | 4990.00         | 5060.00       | 2150.00     | 3560.00       | 56.91           | 29.62           |

The addition of HMT potato starch significantly affected the viscosity of tomato sauce after heating (table 1). The more addition of potato starch shows that the viscosity of tomato sauce both on native starch and HMT potato starch was getting higher. This was due to potato starch acting as a gelling agent thereby increasing the viscosity of tomato sauce. The viscosity of tomato sauce then decreased after sterilization using autoclave at 121 °C for 1 h, but the decrease in viscosity of tomato sauce added by HMT potato starch was smaller than that added by native potato starch. The decreased in viscosity in the use of HMT potato starch was 29.62–68.42% while in the use of native potato starch was 56.91–82.28%. This showed that HMT potato starch increases the stability of the viscosity of tomato sauce during heating.

The native potato starch was more easily damaged during the sterilization by autoclave. The hydrogen bond that connected the starch molecule to water was released during heating, so that the water was released and the viscosity was low. The stability of tomato sauce was greatly affected by the binder or thickener. Water that was bound by the binder caused the viscosity increased. HMT potato starch granules forage interact and trap water and ingredients in tomato sauce strongly, so that viscosity was more stable. Senayake et al. [15] added the hydrothermally modified sweet potato starch to the soup mixture showed that the viscosity of the soup mixture was more stable during storage. Tomato sauce which added by HMT potato starch was then evaluated for sensory properties both before and after sterilization.

3.3. Sensorial evaluation

![Sensorial evaluation diagram]
Figure 2. Sensory evaluation of tomato sauce from various addition of HMT potato starch 0.5% (-♦-), 1% (-■-), 1.5% (-▲-), and 2% (-x-), before (A) and after sterilization (B).

Based on figure 2, it shows that there was a significant difference in the panelist preference for sensorial properties between the addition of HMT potato starch treatment and between before and after sterilization. The panelists' preference for tomato sauce before sterilization showed that more addition of HMT potato starch increased the preference of panelists for the viscosity or thickness of tomato sauce, but the addition of too high HMT potato starch caused the tomato sauce to be too thick and less favorable for panelists. It appears that the panelists did not like the viscosity and overall acceptability of tomato sauce at an addition of 2% HMT potato starch. However, the panelists' preference for viscosity increased in the higher addition of HMT potato starch for the tomato sauce after sterilization, but there was no significant difference between the 1.5% and 2% treatments with a score about 3.1 (figure 2b). The addition of starch as a thickening agent was very effective in improving the quality of food viscosity [15,16].

The addition of HMT potato starch also affected the color of tomato sauce, especially after sterilization. The panelists did not like the color of the tomato sauce at the addition of 0.5%. The changes in viscosity that become too runny affected the perception or liking of the color because the sauce becomes less bright or faded. The higher addition of HMT potato starch increased the panelists' preference for the color of tomato sauce, but the addition more than 1.5% did not differ significantly with a score of about 3.3. The addition of HMT potato starch also affected the taste of tomato sauce. The panelists did not like the taste of tomato sauce in addition of 0.5% after sterilization because the amount of water released from the gel system made it tasteless on the tomato sauce taste. The same thing happened on flavor. Tomato sauce whose binder was slightly more easily damaged by its flavor compounds due to high temperatures. This was due to the flavor compounds were not well protected so that they can be easily damaged or off-flavor. The starch can act as a good binder on taste and flavor compounds [17]. Panelists did not like the flavor of tomato sauce at the addition of 0.5% HMT potato starch, but the addition of 1%–2% panelists liked it. In overall acceptability, the more addition of HMT potato starch, the more panelists liked it, but the addition of more than 1.5% did not differ significantly with a score of about 3.3. Thus the addition of 1.5% potato starch HMT was the optimal treatment to produce a tomato sauce that was stable to heating and favored by panelists.
4. Conclusion
The addition of HMT potato starch var. Granola increased the viscosity stability of tomato sauce. The addition of HMT potato starch to tomato sauce by 1.5% produced the best characteristics, after sterilization with autoclave only decreased viscosity by 32.84% compared to native potato starch (60.68%) with a degree of preference for viscosity, color, taste, flavor, and overall acceptability about 3.1, 3.2, 3.3, 2.9, and 3.3 respectively, were in the rather like category.

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