CHAPTER IV

DISCUSSION AND CONCLUSIONS

1. Evaluation of the properties of the modified starches

1.1. Determination of degree of substitution

In this study, the five raw native starches ; rice, glutinous rice, corn, tapioca and potato starches, were substituted by three different methods.

Carboxymethylation method 1, 2 and 3 produced modified starches in different degree of substitution (D.S.). Method 3 produced modified starches with the highest D.S. might be due to the native starch used as a raw starch in the reaction of this method was dried in order to keep moisture content about 2%. The drying at a high temperature promoted the formation of cavities or fissures in starch granules and caused the increasing in the total surface area available for reaction (Roberts,1965). Therefore, the increasing in the reactivity of method 3 was obtained. Although method 2 had a higher temperature and a higher amount of sodium hydroxide than method 3 had and these factors could enhance the starch reactivity, the D.S. produced by method 2 was lower. It was not surprised to find this because it has been observed that the starch in the mixture became a dought during the reaction, resulting in the

decreasing of surface area and therefore the starch reactivity was decreased. On the other hand, method 1 produced modified starches with the lowest D.S. because of the lowest temperature and the lowest sodium hydroxide content used in the reaction.

1.2. Determination of the functional group

From IR spectra, it was insisted that the carboxymethyl groups were substituted into starch molecules and the band which indicated that the substitution occured was an intense band near 1600 cm^{-1}.

1.3. Moisture determination

The percent moisture content of all modified starches produced by any method was not significantly different. An average value of percent moisture content was mostly ranging from 9.60-13.75%.
Era-Pac^R and Era-Gel^R , partially and fully pregelatinized starches, as comparative binders in this study also had percent moisture content in this range.

From the results, it concluded that the method of carboxymethylation did not influence the percent moisture content of the products.

1.4. Viscosity measurement

Figures 11-15 display the Brabender viscosity curves of various modified starches and their native starches and Figure 16 displays the Brabender viscosity curves of Era-Pac^R and Era-Gel^R. Comparing among five types of the native starches showed that their viscosity and their viscosity curves were different. The viscosity curve during the cooking cycle of rice starch showed a two-stage swelling property. This have been suggested that there were two unequal sets of bonding forces within the granule. Moreover, the viscosity of rice starch rose again when the cooling cycle was reached. it could be explained that the molecules of rice starch reassociated with the adjacent molecules, causing the rise in the viscosity. The viscosity of glutinous rice starch was not seen at any temperature might be due to the concentration of the suspension was too low. Typically, the rise in viscosity occured when the granules had swollen to such an extent that they occupied proportion of the total volume and were in contact with their immediate neighbours (Collison,1968). To prove this assumption, the glutinous rice starch suspension at 5% w/w was subjected to determine the viscosity and found that the viscosity was higher than of glutinous rice starch suspension at 2% w/w (see Figure 94 in Appendix B) and it was higher than of rice, corn and tapioca but slightly less than of potato starch. Native corn starch gave a relatively low viscosity curve, because there was lipid in corn starch molecules, forming complex with amylose and inhibiting granule swelling (Rutenberg,1980). Moreover, corn starch was greater thermal stability so the decreasing in the viscosity was not observed when the temperature increased (Collison,1968). From the Figures, it was

observed that the viscosity of native tapioca and potato starches was higher than of native rice and corn starches. The results were in agreement with Greenwood and Das Gupta who suggested that common cereal starches (rice, corn) had a lower viscosity than tuber (potato) and root (tapioca) starches because cereal starches had more compact structures than tuber and root starches had (Collison,1968). Comparing between tapioca and potato starches, potato starch had a greater viscosity than tapioca starch had, although the concentration of potato starch suspension was only 2% w/w. This was partly due to the presence of ionizable esterified phosphate groups, which assisted swelling by the effect of electrical replusion (Collison,1968).

Comparison of native and modified starches, the modified starch was more viscous than the native starch. This could be explained by the fact that the introduction of carboxymethyl groups into starch molecules disrupted the hydrogen bonding within the granules, enhanced the water dispersibility and caused the high swelling of the granules and the high viscosity of the starch paste (BeMiller,1993 ; Leach,1965 ; Rutenberg, 1980). In addition, the swelling of the granules and the viscosity were much more pronounced by the electrostatic replusion of the carboxymethyl group. During cooking cycle, the viscosity curves of most modified starches tended to decrease. This phenomenon could be explained that, when the modified starch granules contacted with water, they absorbed water, swelling to many times their original volume. These highly swollen granules became increasingly susceptible fragility by heat. Therefore, as the temperature rose, the collapse of the granules increased and resulting in the decreasing of the viscosity (Leach,1965). Normally,

when the cooling cycle reached, the starch molecules moved slowly and began to reassociate with the adjacent molecules, and the increasing of the viscosity resulted. With carboxymethyl starch, this phenomenon did not appear because carboxymethylation reduced the hydroxyl number and decreased the reassociation of the molecules (Rutenberg,1980). Consequently, the viscosity of the modified starch tended to be constant during cooling period. As can be seen from the Figures, the viscosity of modified rice starch and modified glutinous rice starch produced by three methods was rank in the order as followed MRS1 ~ MGS1 > MRS3 ~ MGS3 > MRS2 ~ MGS2 whereas the viscosity of modified tapioca starch and modified potato starch was rank in the order : MTS2 ~ MPS2 > MTS1 ~ MPS1 > MTS3 ~ MPS3. Typically, the higher temperature was, the lower viscosity of a starch paste obtained due to the degradation of the starch molecules by the high temperature (Collison,1968). Inversely, the viscosity of the tapioca and potato starch pastes produced by method 2 exhibited the highest might be due to the gelatinization of the starch molecules of tapioca and potato dominated over the the degradation of the starch molecules. Dostal found that the granules of root and tuber starches were less heat resistant than of cereal starch (Collison,1968). Therefore, the gelatinization of tapioca and potato starch occured in greater extent. Moreover, the tapioca and potato starches had larger granules than rice, glutinous rice and corn had so they could swell several hundredfold and occupied the total volume, causing high viscosity.

With Era-Pac^R and Era-Gel^R , the viscosity of Era-Pac^R was higher than of Era-Gel^R and its pattern was the same as the pattern of native rice starch. This could easily explained that Era-Pac^R was a partially

pregelatinized rice starch. So, the starch granules were partially pregelatinized and they still behaved like native rice starch granules. On the other hand, Era-Gel^R starch granules were completely pregelatinized and the swollen granules were damaged by the production process, causing the reduction in viscosity but in this investigation the viscosity of Era-Gel^R was not noted due to the concentration was too low.

2. Evaluation of granule and tablet properties

2.1. Evaluation of the physical properties of paracetamol granules and tablets containing various types, degrees of substitution and percentages of the modified starches.

In this step concerned about the investigation of the binding property of various modified starches and the comparison of the binding property of these modified starches to their native starches.

2.1.1. Particle size distribution

The particle size distribution of paracetamol granules granulated with various native and modified starches either in a dry or a paste form was previously shown in Figures 17-46 and Tables 17-22 (in appendix C). It could be seen that, by solution incorporation method, native starches exhibited wider size distribution than modified starches did. D_{50} of the granules using a native starch was slightly smaller than of a modified starch.

From the log-probability plots (see in appendix C), it was observed that the regression lines of either modified starch or native starch at any concentration were parallel and not significantly different. This result implied that the binder weight in formula did not significantly affect the D_{50} value or might be implied that the range of the binder weight employed in this study was not sufficient difference to show the effect of the amount of binder weight. This aspect also happened in the regression lines of a modified starch at various degrees of substitution. Therefore, it could be concluded that the degree of substitution did not affect D_{50} of the granules. Although the concentration and the degree of substitution did not affect the size distribution and the D_{50} value, the incorporation method influenced these properties. As can be seen from the data previously showed, the dry incorporation method produced the granules using modified starch as a binder slightly larger than did the solution incorporation method and the size distribution of the granules obtained by the dry incorporation method was narrow in comparison to which obtained by the solution incorporation method. It was hardly to conclude that the dry addition method was more effective than another method because the other physical properties of paracetamol granules and tablets, which will be discussed later, produced by this method was not better than those produced by the solution addition method. It was probably due to non-uniform distribution. With the dry addition method, a binder was dry mixed with drug and diluent before water was added. This could promote the distribution of the dry binder. In addition, the distribution of the dry binder was better than of the viscous paste. Therefore, the better agglomeration of the powder after the water was added obtained. However, it has been observed that the dissolving

process of the modified starch took an appreciable length of time. With the dry addition method, the wetting process might allow the modified starch to dissolve in some degrees which might be enough to produce large agglomerates but might not be sufficient to produce strong binding bonds. This meant large but fragile agglomerates were obtained. On the other hand, with the solution addition method, the binder was added to the powder mix as a paste form which was quite viscous so it could not controll the volume of each adding but the mixing time in each addition of the binder was controlled. Therefore, the non-uniformity of the paste might occur. Although the distribution of the paste less uniform than of the dry binder, it had stronger binding strength.

2.1.2. Bulk density, tapped density and percent compressibility

Tables 5 and 6 display bulk density, tapped density and percent compressibility of the granules granulated with native and modified starches by solution and dry incorporation method, respectively. It was observed that the granules using the native starch exhibited lower bulk density and higher percent compressibility than did those using modified starches while their tapped densities were nearly equal. With the D_{50} value of the granules using native starches, the D_{50} value did not relate to the bulk density and the percent compressibility because it was generally known that small granules were able to form a close packing and resulted in high bulk density and low percent compressibility. This might be explained that, the native starch granules formed loosely agglomerates so lower bulk density and higher percent compressibility was observed. When the agglomerates were tapped, the agglomerates

were brokendown by the tapping force, causing the particle size reduction. As this result, the tapped density of the granules using the native starches was equal to which of the granules granulated with the modified starches. This could also be explained that smaller D_{50} obtained from the native starches was probably due to sieve-shaking force.

As previously mentioned, the size distribution of the granules using various degrees of substitution and concentrations was not different. Consequently, the bulk density, the tapped density and the percent compressibility of the granules using various degrees of substitution and concentrations exhibited similar. Comparison of solution and dry incorporation methods, the tapped density and the percent compressibility of the granules produced by solution incorporation were higher than of which produced by the another method because the solution incorporation method produced wider distribution and the smaller of the size distribution occupied interstices between the larger particles when the powder bed was tapped, causing a higher tapped density and a higher percent compressibility. Another expectation was that the granules obtained by the dry incorporation method were more porous than those obtained by the solution incorporation method.

2.1.3. Flow rate and angle of repose

From Tables 7-8, the effects upon the flow rate and the angle of repose by various types and concentrations of the modified starches were not clearly defined. The granules produced by the dry addition method exhibited lower flow rate and higher angle of repose than

those produced by the another method. Several investigators demonstrated that, the porosity of the granules was the greatest factor influencing the granulation orifice flow rates (Gold, Duvall, Palmero and Slater,1968 ; Sumner, Thompson, Poole and Grizzle,1966). According to the bulk density, tapped density and the percent compressibility results, the granules prepared by the dry incorporation method were more porous than those prepared by the solution incorporation method. Therefore, it might be concluded that the higher angle of repose and the lower flow rate obtained from the dry addition method were caused by the porosity of the granules

2.1.4. Granule friability

Figures 57-66 illustrate histograms for percent friability of paracetamol granules. It was observed that as an amount of a binder increased, the granule friability slightly decreased due to stronger bond formation.

Comparison of the granule friability between the granules using native starch and modified starch, showed that the native starch produced more friable granules. This meant binding property of the native starches poorer than of the modified starches. Comparing between two incorporation method, the dry addition method produced the granules of slightly friability because the dry binder in the powder mix might not completely gel upon wetting with water as previously discussed. The binding property was probably less than which incorporated as a paste. Therefore, weaker binding bonds within the granules was expected with the dry method.

However, the difference in percent friability of all cases observed in this study was not great. This might be due to the volume of the granules was too low incomparison to the volume of the PVC container used in granule friability testing, consequently the chance that the granules collided each other or collided with the stainless spheres did not cause large impaction.

2.1.5. Tablet thickness

The tablet thickness of all formulations was not different. This could be concluded that the modified starches at any degree of substitution and any concentration, incorporated by either solution or dry addition method, produced the consistent tablet thickness. The tablets using either native or modified starch as tablet binder were not different in thickness.

2.1.6. Tablet hardness

Comparison of the tablet hardness between solution and dry addition method, using modified starch as binder, revealed that the solution addition method produced the tablets of greater hardness. This could be explained on the fact that the modified starch upon wetting with water became gel and exerted greater binding property and the wetting process provided an appreciable length of time to allow it fully hydrated. With the dry addition method, the wetting process might not be sufficient to allow the dry binder fully hydrate. As the result, the less binding strength was obtained from the dry addition method.

Moreover, it was observed that the increasing in tablet hardness as the amount of the binder increased. It could be explained that as the amount of the binder increased, the binding bridges which were responding for the mechanical strength of the tablets were also increased resulting in greater hardness.

By the solution addition method, the hardness of various types of modified and native starches was varied but MRS1, MGS2, MGS3 and MCS3 were in the first three orders of the hardness at any concentration.

All in all, MGS2 as the paste form yielded the hardest tablet, except at 2% level MGS3 gave the hardest tablet. This could be explained on the basis of the fact that, glutinous rice starch was composed entirely of amylopectin (Hixon and Brimhall,1968) and it has been reported by Schwartz and Zelinskie (1978) that the amylopectin fraction imparted the binding strength of the starch. The MGS3 exhibited greater hardness at the high binder level might be due to the high viscosity of the MGS3 affected the uniformity of distribution. It has been reported that the mucilaginous binder distributed less uniform than solution binder (Dingwall and Ismail,1977) but this effect was compensated by the increasing in the volume of a binder paste. The MGS1 was the highest viscous so it could not distributed uniformly.

2.1.7. Tablet friability

Tablet friability was one of the indicators implied the tablet strength. In this study, the tablet friability correlated with the tablet hardness that the more tablet hardness was, the less friability obtained. By solution incorporation method, the tablets using various modified starches were less friable than those using their native starches, except those using MCS1 and MTS1 were more friable. From Tables 11 and 12, it could be stated that the degree of substitution did not influence tablet friability.

Comparison of the tablet friability between solution and dry addition method, using modified starch as binder, revealed that the dry addition method produced the tablets of greater friability. By increasing in the amount of a binder, the decreasing in friability was observed

2.1.8. Disintegration time

With solution incorporation method, the disintegration time of the tablets containing native starches at any concentration was not longer than 1.21 min. It was not surprised to find this since in this investigation the tablet hardness was not controlled and the tablets using various native starches possessed the lowest hardness. Therefore, they could disintegrate easily resulting in the short disintegration time. Morever, the modified starch paste was more viscous than the native starch paste and the modified starch could form a gel barrier decreasing

water penetration into the tablet and retarding the disintegration time (Akande, Deshpande and Bangudu,1991 ; Visavarungroj and Remon,1990).

By increasing binder content either in solution or dry incorporation method, the progressively prolonged in disintegration time was observed. This was probably due to the influence of the binder on the wettability and the penetration of liquid into the capillaries of the tablets. Many papers were shown that the presence of binder in tablet formulations would be expected to reduce the size and number and alter the shapes of the capillary spaces between the particles which were contributing to the transport of water (Adeyemi and Pilpel,1984 ; Zubair, Esezobo and Pilpel,1987 ; Zubair et al.,1988). In addition, Huber, Dale and Christenson (1966) had suggested that binders form thin films around granules during granulation process and form viscous barrier to the penetration of test fluid thus prolonging disintegration time of tablets. These effects were expected to be magnified at higher concentrations of binding agents.

Comparison of the two addition methods, using modified starch as a binder, the tablets produced by solution addition method exhibited longer disintegration time, except at 2% level. This might be due to the stronger bonds obtained from fully hydrated binder or due to the effect of the tablet hardness because in the disintegration time investigation of all tablet formulations did not controll the tablet hardness to the same degree. Inversely, at 2% level, the tablets produced by solution addition method showed shorter disintegration time although

these tablets exhibited greater hardness. From the composition of paracetamol tablet formulations in dry addition method as previously shown in the experimental method, the volume of the water in all formulations was equal. Hence, the amount of the dry binder wetted by the limitted amount of the water in all formulations might be nearly equal. The unwetted binder in the tablet might be increased as the amount of the total dry binder increased. This unwetted binder could swell upon wetting during disintegration testing, forming a gel barrier, decreasing water penetration into the tablet and retarding the disintegration time. As the result, the increase in disintegration time was observed as the unwetted binder in the tablet increased. This meant the longer disintegration time was obtained as the amount of the total binder in a formulation increased.

2.2. Selection of the formulation which exhibited good physical properties

This step concerned about the selection of the best formulation from all formulations which were evaluated in the former step.

To select the best formulation, the physical properties of paracetamol granules and tablets would be considered but the granule properties of various types and degrees of substitution of the modified starches shown in this study were much different. Therefore, the physical properties of paracetamol tablets were used to consider.

As it was seen, the tablets produced by the solution incorporation method exhibited better physical properties than those produced by the dry incorporation method. Moreover, the physical properties of the tablets produced by various modified starches were better than of those produced by their natives. Comparison among various types and degrees of substitution of the modified starches, MGS2 was the best binder. Although MGS3 at 2% level showed slightly harder tablets than MGS2, it also showed much longer disintegration time. So, MGS2 was chosen to compare with reference binders for further studies.

2.3. Comparison of the selected formulation obtained from 2.2 with the formulations containing other available binders.

This step concerned about the comparation of the binding property of MGS2 with the other available binders. PVP K30 and Era-Gel^R were used as reference binders because PVP K30 was the best and the most popular binder for paracetamol tablets and Era-Gel^R was a physical modified starch which is introduced to be used as a binder in the present. The evaluation of the physical properties of paracetamol granules and tablets were the same as mentioned in the step 2.1

2.3.1. Particle size distribution

The particle size distribution of paracetamol granules granulated with MGS2, PVP K30 or Era-Gel^R in solution form was previously shown in Figures 87-89. It was seen that the size distribution of paracetamol using PVP K30 was slightly narrower than which using

MGS2 and Era-Gel^R. D50 (Figure 90) of granules using MGS2 and Era-Gel^R were nearly equal and they were smaller than of granules using PVP K30. This might be due to PVP K30 was a solution binder so it could distribute more uniform than MGS2 which was a mucilaginous binder. Although the viscosity of Era-Gel^R solution was very low, D50 value exhibited smaller. This meant the binding bond produced by Era-Gel^R was very weak. This assumption was supported by the other properties which would be discussed later on.

2.3.2. Bulk density, tapped density and percent compressibility

Table 13 displays the bulk density, the tapped density and the percent compressibility of paracetamol granules using MGS2, PVP K30 or Era-Gel^R in solution form as the binder. It was found that the granule using Era-Gel^R exhibited both the lowest bulk density and the highest tapped density. In general, small particles occupied interstices between large particle creating a densely packed powder and causing a high bulk density (Fonner et al.,1981). However, Era-Gel^R showed inversely. This indicated these granules formed loosely agglomerates and caused low bulk density result. When the agglomerates were tapped, the tapping force broke down these agglomerates and reduced particle size. Therefore, the highest tapped density and the highest percent compressibility were obtained.

2.3.3. Flow rate and angle of repose

The flow rate and the angle of repose of the granules using MGS2, PVP K30 or Era-Gel^R were nearly equal at any concentration.

2.3.4. Granule friability

Figure 91 shows histograms for the percent friability of paracetamol granules. It was observed that as the binder weight increased, the friability decreased. This result was in agreement with many reports which was published that an increase in amount of the binder in the granulation, the granules of greater strength resulted (Davies and Gloor,1972 ; Ganderton and Selkirk,1970 ; Harwood and Pilpel,1968 ; Jaiyeoba and Spring,1980). At 1% binder weight, The percent friability produced by Era-Gel^R was the highest, then MGS2, and then PVP K30. At 1.5 and 2% level, the percent friability of the granules using MGS2 was equal to which using PVP K30 and lower than of which using Era-Gel^R . These results showed again the poor binding property of Era-Gel^R in comparison to MGS2 and PVP K30.

2.3.5. Tablet thickness

MGS2 provided the least thickness, then PVP K30, and then Era-Gel^R. This might be due to the size distribution of the granules using MGS2 was wider than which produced by PVP K30 and the

samller particles could fill voids of the larger particles creating compact and less porous tablet (Fonner et al.,1981). For Era-Gel^R, the granules using Era-Gel^R possessed the highest tablet thickness although they also showed wide size distribution. It was possibility due to the granules had the lowest density or it could say that intragranular porosity of the granules using Era-Gel^R exhibited the highest. Generally, the reducing of mean pore diameter could increased granules strength (Fonner et al.,1981). Therefore this assumption could be supported by the percent friability that the granules using Era-Gel^R produced the highest friability so this might mean that they had the lowest density. Another explanation might be the granule shape produced by Era-Gel^R was irregular so the granules could not rearrange to form a closely packed system. The concentration of these three binders did not affect the tablet thickness.

2.3.6. Tablet hardness

By ANOVA test, it showed that the tablets produced by MGS2 were harder than which produced by Era-Gel^R at any concentration. At 1.5% and 2% binder weight, the MGS2 yielded the tablets as strong as the PVP K30 did. This could say that at 1.5% and 2% binder weight, the binding strength of MGS2 was as good as of PVP K30. The hardness increased with the increasing of the binder weight in the formula.

2.3.7. Tablet friability

Percent friability of tablets was another value which indicated binding strength of the tablets. The result showed again that the binding strength of the tablets increased as the binder amount increased. The binding strength of MGS2 was better than of Era-Gel^R but slightly less than of PVP K30.

2.3.8. Disintegration time

From the disintegration time profiles, the disintegration time increased as the binder weight increased, with an exception of PVP K30. The disintegration time of the tablets containing PVP K30 at any concentration was not significant different. The reason which expained about the increasing in disintegration time as the amount of binder increased was previously mentioned in 2.1.8. At certain concentration, The tablets using Era-Gel^R revealed the shortest disintegration time. An explanation for this was that Era-Gel^R produced tablets of the least hardness at all binder weights so water could penetrate into the tablet easily causing the rapid disintegration. With MGS2, the tablets using MGS2 as the binder disintegrated slower than which using PVP K30 although their hardness were comparable. This might be attributed to the swelling of MGS2 after it was wetted with water in the early stages of water penetration resisted further penetration of the water. As the result, the destruction of the tablets was prolonged. On the other hand, PVP K30 did not had the property to swell but it dissolved in

water. Thus the water could penetrated into the tablets using PVP K30 better than the tablets using MGS2 resulting in faster disintegration time.

2.3.9. Dissolution time

In the dissolution test, only the tablets using PVP K30, the reference binder, were chosen to compare with the tablets containing MGS2 because they had similar properties. Moreover, the tablets containing Era-Gel^R revealed poor properties therefore it was unnecessary to test for the dissolution time.

The dissolution profiles of the tablets using MGS2 or PVP K30 as tablet binder which were previously illustrated in Figure 95 showed that both formulations exhibited good dissolution and met the requirement of USP XXII. In addition, it was noted that, in the early stages of dissolution, the tablets containing PVP K30 imparted faster dissolution time than those containing MGS2. However, the complete dissolution of the tablets using PVP K30 as the binder was not obtained. This might be due to the interaction between the excipients. Chowhan and Chi (1986) have ever been disscussed about this phenomenon and they concluded that the decreased in the drug-dissolution rate was caused by the adhesion of the magnesium stearate flakes to the drug-crospovidone agglomerates.

CONCLUSIONS

On the basis of the above results several conclusions could be drawn at follows.

1. The physical properties of paracetamol granules containing various types and degrees of substitution of the modified starches were much different.

2. The effect upon the physical properties of tablets by the degree of substitution could not be clearly defined.

3. Comparison between solution and dry incorporation methods, using modified starch as a binder, the tablets produced by solution incorporation method were harder and less friable than those produced by another method but they disintegrated slower except at 2% binder weight.

4. Comparison among various types and degrees of substitution of the modified starches, modified glutinous rice starch at D.S. of 0.35 (MGS2) was the best binder. It provided the hardest tablets with short disintegration time, except at 2% binder weight, the tablets using MGS3 was the hardest but they also disintegrated slower.

5. MGS2 as paste form was chosen to compare with polyvinylpyrrolidone K30 (PVP K 30) and Era-Gel^R and the results showed that

    - MGS2 provided harder tablets than Era-Gel^R. Moreover, it gave tablets as strong as PVP K30 did, except at 1% binder weight.

    - The tablets using MGS2 was less friable than those using Era-Gel^R but more friable than those using PVP K30

    - The rank order of disintegration time was ranging from Era-Gel^R < PVP K30 < MGS2

- As the binder weight in the formulation increased, the hardness increased, percent friability decreased and disintegration time increased (except PVP K30).

6. From the dissolution test, MGS2 and PVP K30 gave tablets which exhibited complete dissolution within 20 minutes.

7. Sodium carboxymethyl starch prepared with proper type of starch and optimum D.S. offered advantage over native starch. It could form viscous gel when directly contact with cold water without the step of preparing starch paste by heating.

Under the observation from this study, the interesting points were recommended for further study.

1. The effects of the variables in carboxymethylation process such as reaction temperature, reaction time and concentration of sodium hydroxide on the degree of substitution and properties of the modified starch product should be investigated.

2. The molecular weight and molecular arrangement of the modified starches product should be determined in order to relate with their physical properties.

3. The investigation of the influences of amylose-amylopectin fraction on binding characteristic of the modified starch was very interesting.