Results and Discussion

Native corn starch are insoluble in water. It have internsic properties (high viscosity, low solubility and low swelling power) these properties minimize its uses in many industries.

In this work three modified starches (thin boiling starch, oxidized starch and starch phosphate) were prepared and analyzed.

Native corn starch

Native corn starch was analyzed for moisture %, protein %, crude fat % fiber % and Ash % as described in **A.O.A.C.(1995)** the results are given in the table(1)

The solubility and swelling power of native corn were determined and the results are recored in table (2) and figure (1)

The apparent viscosity of native corn starch was determined and the results are illustrated in table (3) and figure (2)

The results form table (2) figure (1) show that the solubility and swelling power of native corn starch at 20℃ and 50℃ are very low (1 to 1.7%) and these values was increased to 12.7 and 11.3 at 90℃ respectively.

The results in table (3) figure 2 show that the apparent viscosity of native corn starch at 90℃ was very high (5260 C.P.S). the viscosity was increased by decreasing the temperature of the determination.

Table (1): Analysis of native corn starch

Components	**(%) on dry basis**
Moisture	11.7
Protein	0.35
Crude fat	0.5
Crude fiber	0.3
Ash	0.1

Table (2):The solubility and swelling power of native corn starch

Solubility %			**Swelling power %**		
20℃	50℃	90℃	20℃	50℃	90℃
1	1.4	12.7	1.7	1.32	11.3

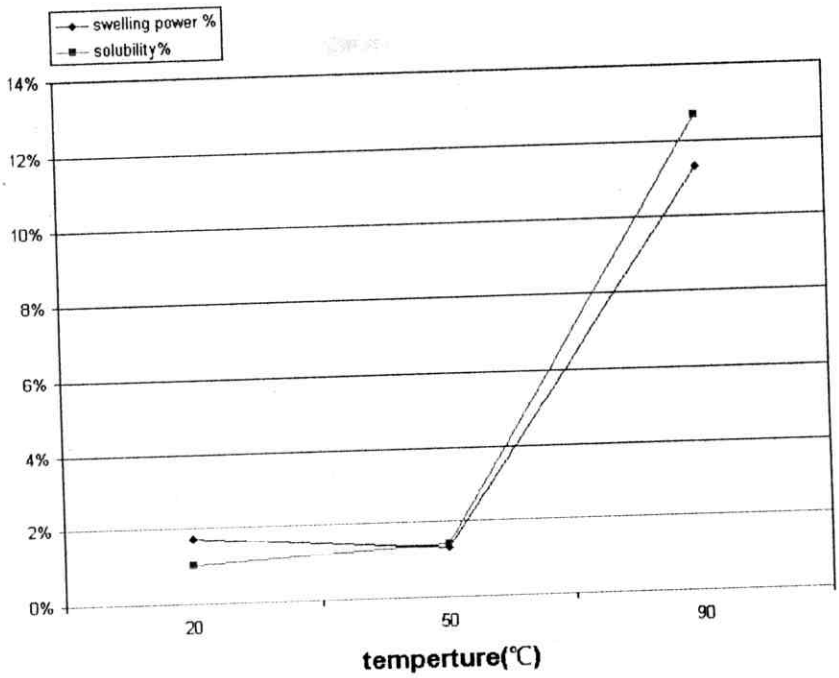
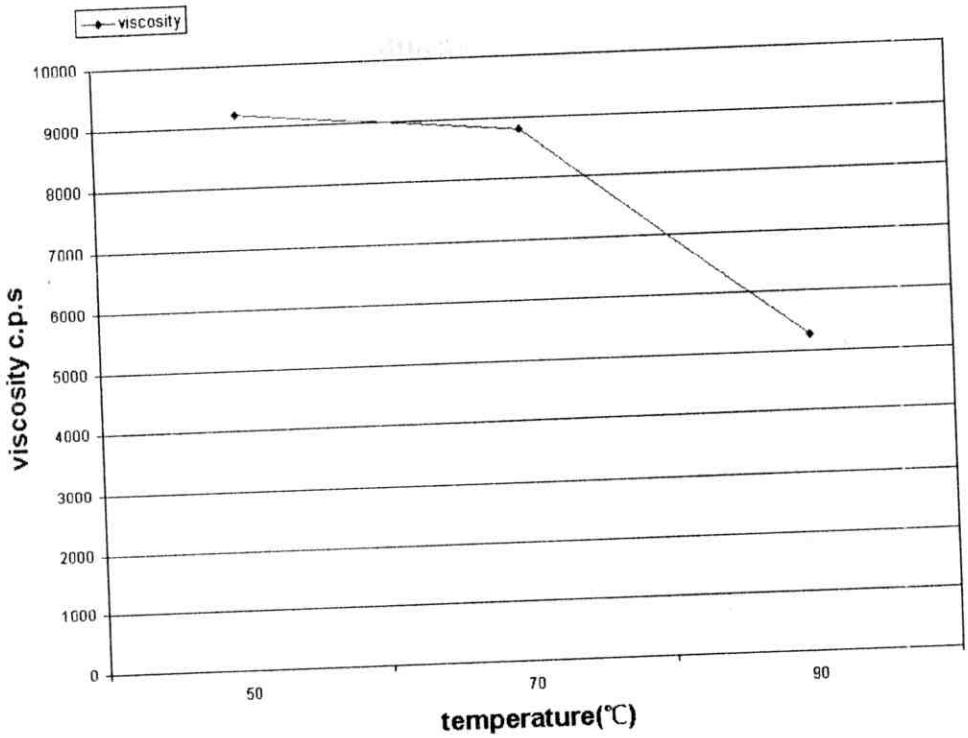


figure (1) solubility and swelling power of native starch

Table 3 :The apparent viscosity of native corn starch

Temperature ℃	Viscosity C.P.S
20	out of range
50	9200
70	8800
90	5260



figure(2) viscosity of native starch.

1. Thin boiling starches

Three procedure (1-1, 1-2 and 1-3) were carried out to prepare three samples of thin boiling starch.

The solubility and the swelling power were determined and results were listed in table (4) and figure (3), (5) and (7).

The results in table 4, figure 3,4 and 5 showed that the solubility of thin boiling starch was very high (78-94%) especially at 90℃ by comparison these values with the solubility of native corn starch (12.7%) at 90℃. The swelling power of thin boiling starch at 90℃ reached to 32-37 and this value was higher than the swelling power of native corn starch (11.3).

The apparent viscosity of thin boiling starch was determined and the results are recorded in table (5) and figure (4), (6) and (8).

The results in table (5) and figure (4), (6) and (8) showed that the viscosity of thin boiling starch samples at different temperature of measurements are very low with comparison the viscosity of native corn starch. The viscosity of thin boiling starch at 50℃ ranging from 28 – 48 C.P.S in contrast the viscosity of native corn starch at 50℃ equal 9220 C.P.S.

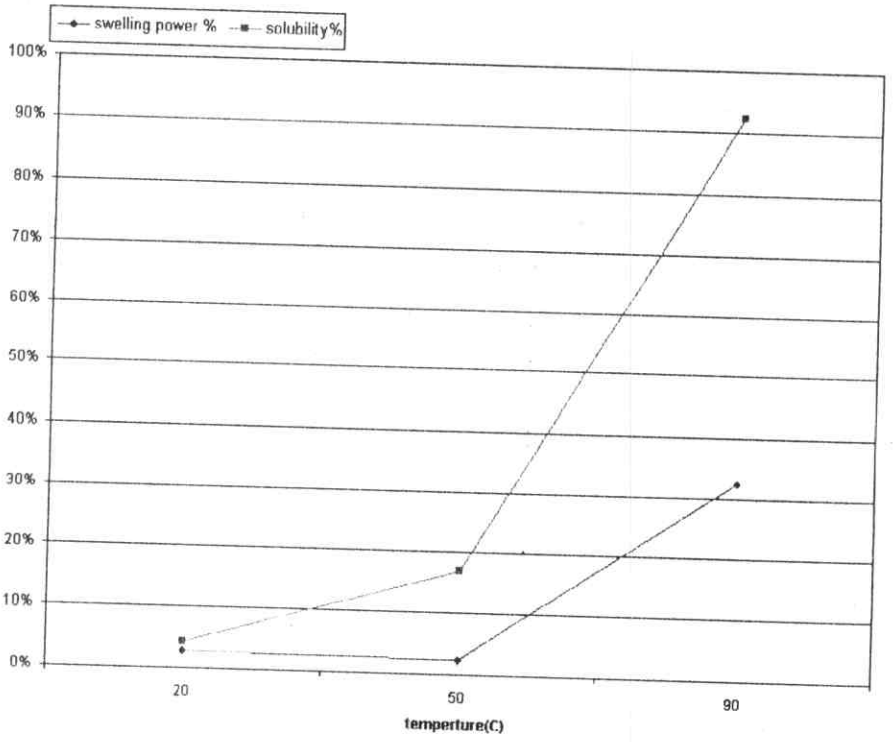
It is concluded that the thin boiling starch is still birefringent and the acid attacks the starch in the amorphous area of the granule more rapidly than in the crystalline areas. The amylopectin in the granule is degraded more rapidly than the amylose. The degradation of the amylopectine and Amylose increased the solubility and decreased the viscosity of thin boiling starch. The results of solubility and viscosity of thin boiling starch are in agreement with **Shildneck and Smith (1967) and Whistler et al, (1984).**

Table 4:The solubility and the swelling power of thin boiling modified starch

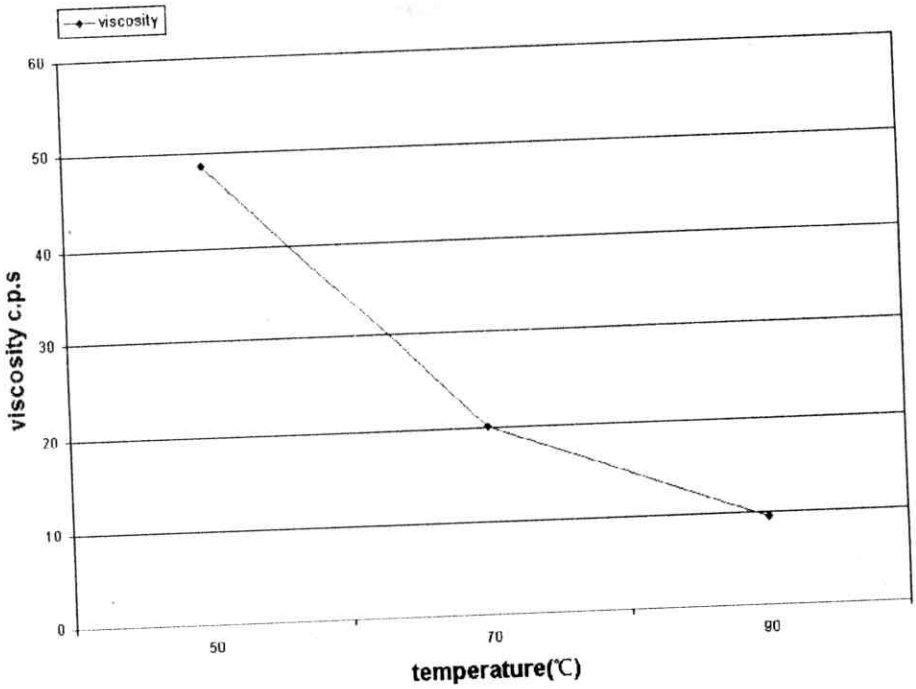
Treatment No.	Solubility %			Swelling power %		
	20℃	50℃	90℃	20℃	50℃	90℃
Treatment 1-1	4.09	16.9	92.33	2.63	2.27	32.5
Treatment 1-2	4.09	8.09	78.08	3.04	1.86	33.7
Treatment 1-3	4.54	19.95	94.23	2.35	4.6	37.8

Table (5) :The apparent viscosity of thin boiling starch

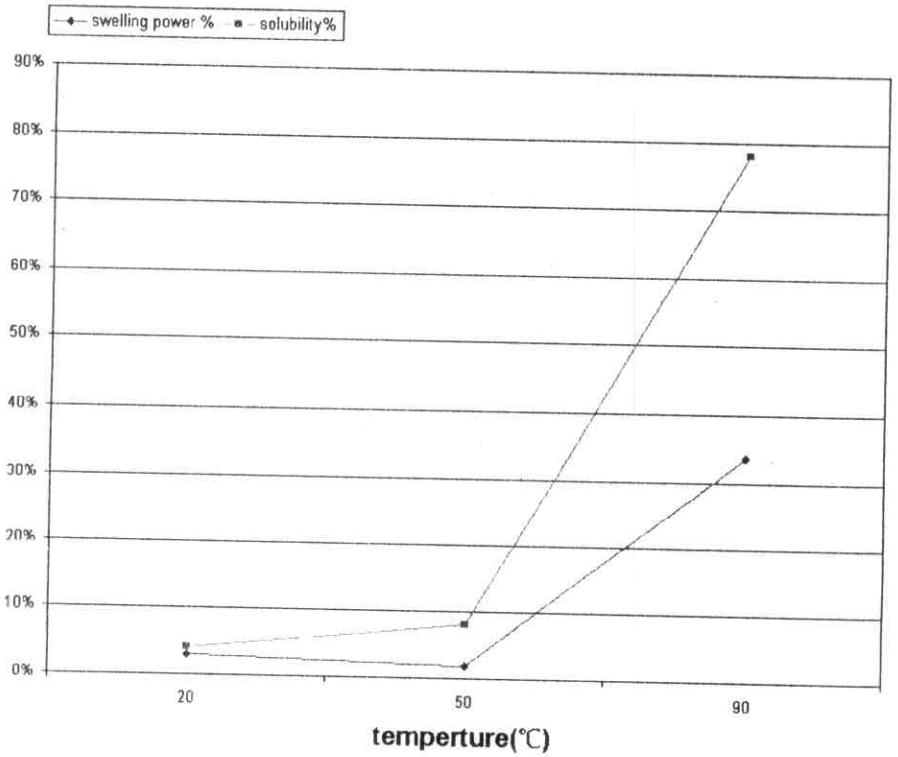
Treatment No.	Apparent viscosity C.P.S			
	20℃	50℃	70℃	90℃
Treatment 1-1	1250	48.6	20.12	9.5
Treatment 1-2	523	35.6	17.20	7.3
Treatment 1-3	209	28.4	14.30	5



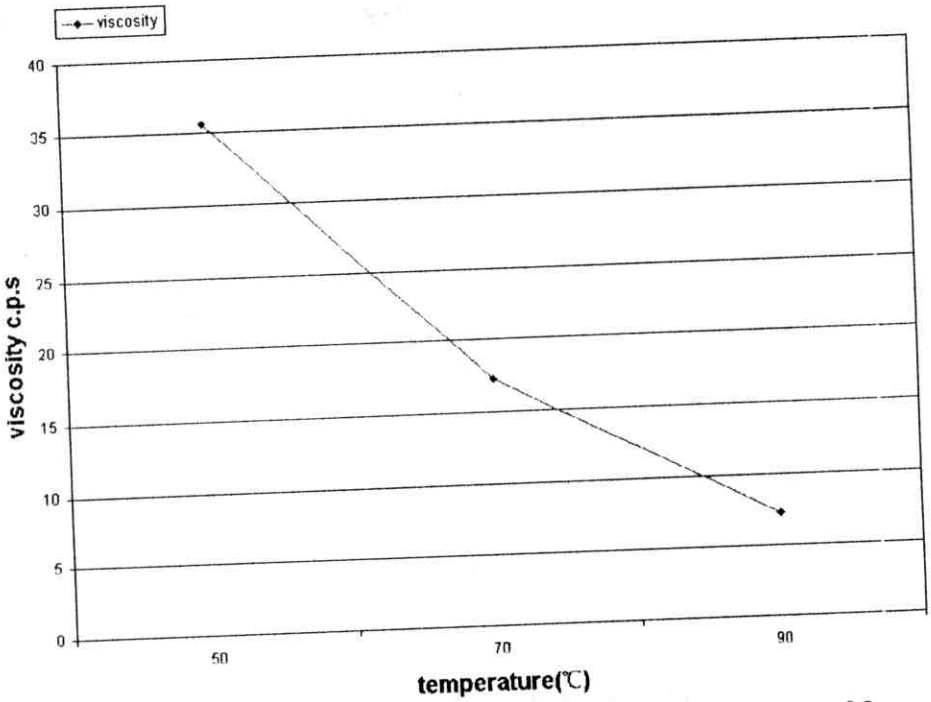
figure(3) solubility and swelling power of thin boiling starch by phosphric acid.



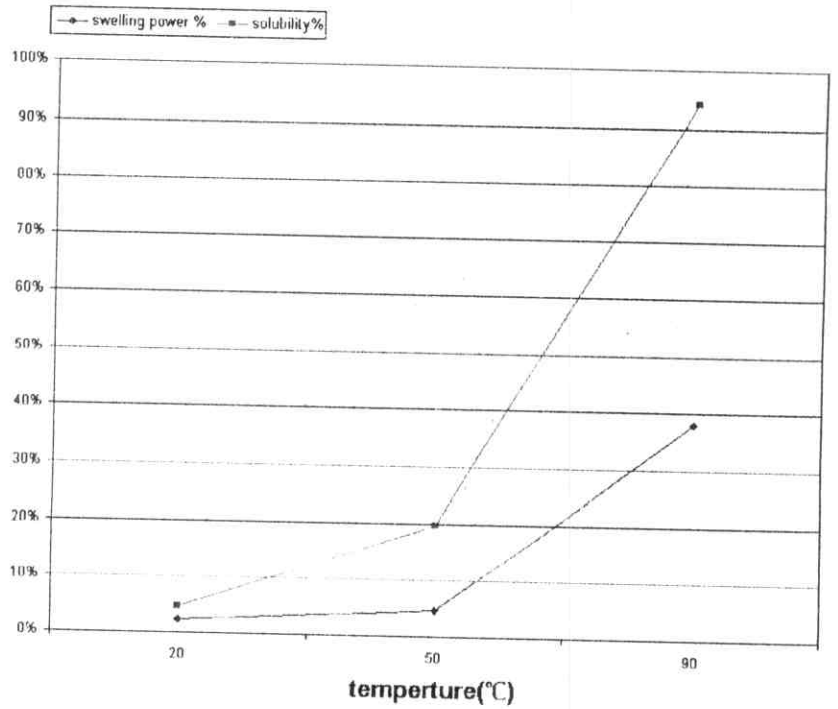
figure(4) viscosity of thin boiling starch by phosphirc acid.



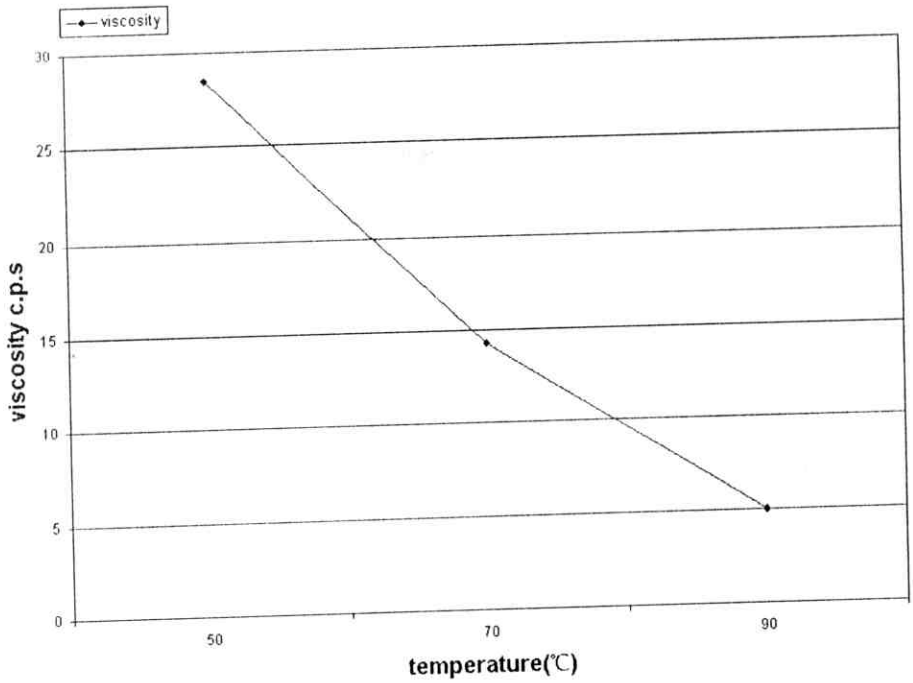
figure(5) solubility and swelling power of thin boiling starch by hydrochloric acid.



figure(6) viscosity of thin boiling starch by hydrochloric acid.



figure(7) solubility and swelling power of thin boiling starch by phosphoric acid and hydrochloric acid.



figure(8) viscosity of thin boiling starch by phosphoric acid and hydrochloric acid.

2. Starch phosphate:

Starch phosphate (procedure 2) was analyzed, the results are recorded in table (6) and figure (9)

The results in table (6) and figure (9) showed a stable increased in solubility with increased the temperature of solubility determination.

The solubility at 90℃ was very high (97.8).
The solubility in figure(9) give a strait line.

The swelling power also was very high especially at 90℃ (433) and at 20℃ and 50℃ the swelling power was high (42.59 and 82.68) by comparison with the swelling power of native starch, thin boiling starch and oxidized starch.
The results in table (7) and figure (10) showed that the apparent viscosity of starch phosphate at 90℃ was 322 C.P.S.

These viscosity was increased by decrease the temperature of viscosity determination.

The above results was obtained by treament.
The native corn starch with sodium dihydrogen phosphate and sodium hydroxide solution and the mixture was heated at 160℃ for 3 hours.

These treatment introduce highly negative charge group (phosphate) on the starch molecules which in trap high quantity of water that increased the solubility and swelling power.

The chemical component in the starch mixture and high temperature depolymerize the starch molecules and decrease the viscosity to (322 C.P.S at 90℃). the starch phosphate granules lost their birefringense.

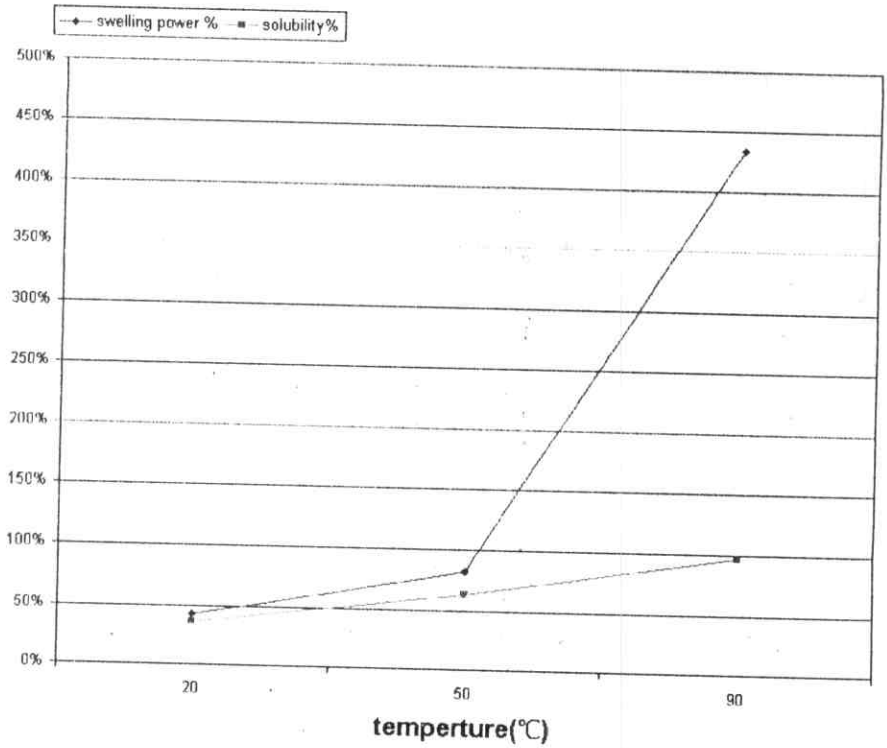
The results above was in agreement with **Ojima and Yamamoto (1986) Marusza and Tomasik (1991) Lim and Seid (1993) and Waly et al (1994).**

Table (6) :The solubility and swelling power of starch phosphate

Treatment No.	Solubility%			Swelling power%		
	20℃	50℃	90℃	20℃	50℃	90℃
Treatment 2	36.9	64.13	97.8	42.59	82.68	433

Table (7): The apparent viscosity of starch phosphate

Temperature ℃	Viscosity C.P.S
20	4580
50	3500
70	1300
90	322



figure(9) solubility and swelling power of starch phosphate.

dispersion viscosity, higher solvbility and introduce carbonyl and carboxyl groups which retard recrystallization.

Hydrogen peroxide oxidation introduced considerably more carbonyl groups than hypochlorite.

The oxidizing agent has been claimed to penetrate deeply into the granule, acting mainly on the amorphous regions. On the other hand the oxidation rate was reported to be higher when oxidation was conducted in gelatinized starch dispersion as compared with granule suspensions.

Carbonyl and carboxyl groups in oxidized starch are hydrophilic properties, which attracts more quantity of water and gave a stable properties from solubility, swelling power and viscosity.

From economical point of view the oxidation of starch by hypochlorite by using dry methods give the best properties for oxidised starch.

These results are in agreement with **Prey and Siklossy (1971) and Forssell et al (1995) and Parovuori et al (1995).**

Table (8):The solubility and swelling power of oxidized starch

Table (8):The solubility and swelling power of oxidized starch

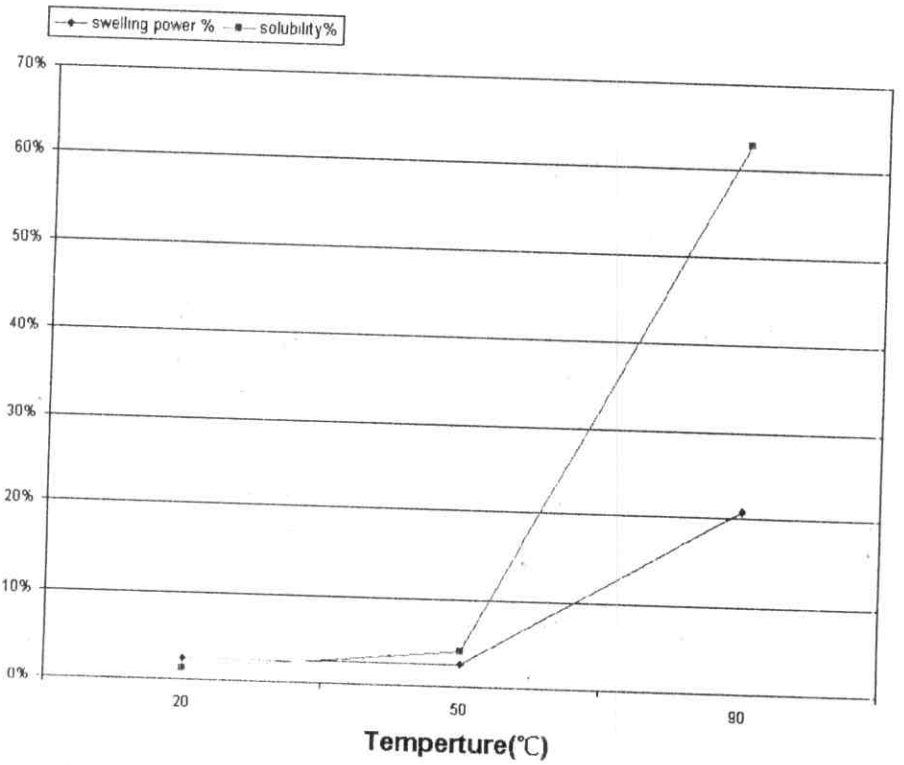
Treatment No.	Solubility %			Swelling power		
	20	50	90	20	50	90
Treatment 3-1	1.36	4.09	62.8	2.53	2.68	20.8
Treatment 3-2	1.09	3.45	55.2	1.95	2.07	21.3
Treatment 3-3	19.36	28.77	91.0	2.62	2.40	30.4

Table(9):The apparent viscosity of oxidized starch

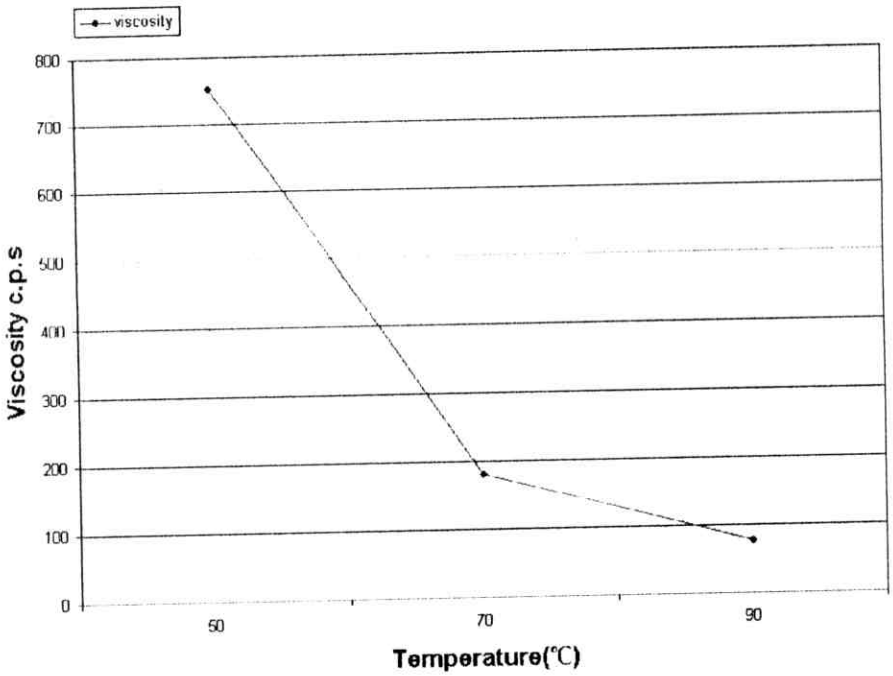
Treatment No.	Apparent viscosity C.P.S			
	20℃	50℃	70℃	90℃
Treatment 3-1	6450	755	182	76.7
Treatment 3-2	7280	564	394	113.0
Treatment 3-3	254	144	84.3	14.1

Table(10):The carbonyl and carboxyl content of oxidized starch

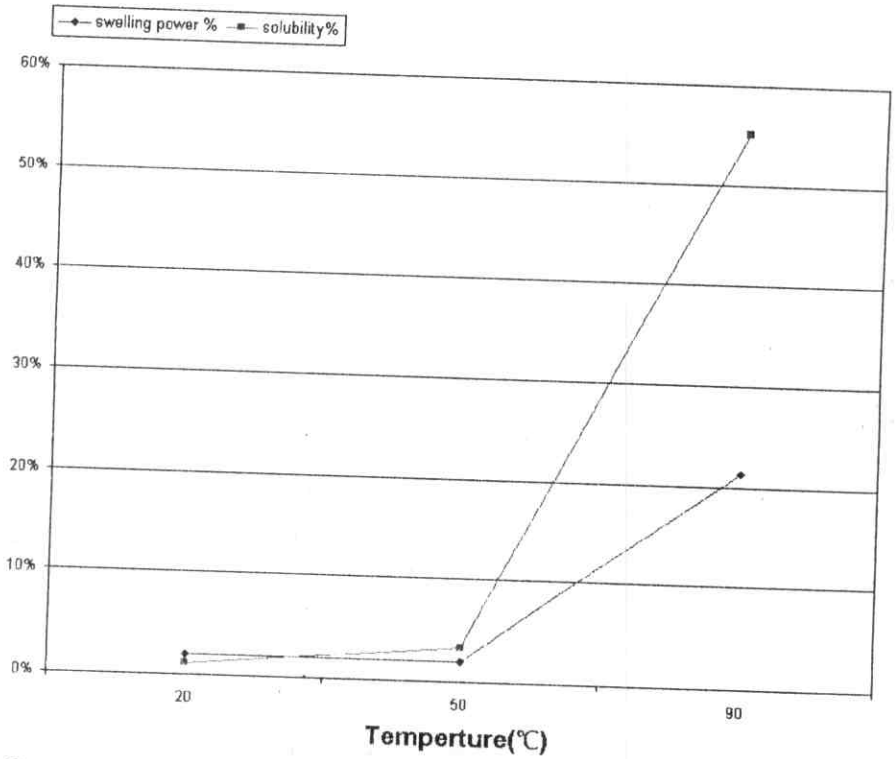
Treatment No.	Starch samples	Carbonyl Content %	Carboxyl Content %
3-1	Oxidized starch	2.8	0.4
3-2	Oxidized starch	2.6	0.5
3-3	Oxidized starch	0.5	1.2



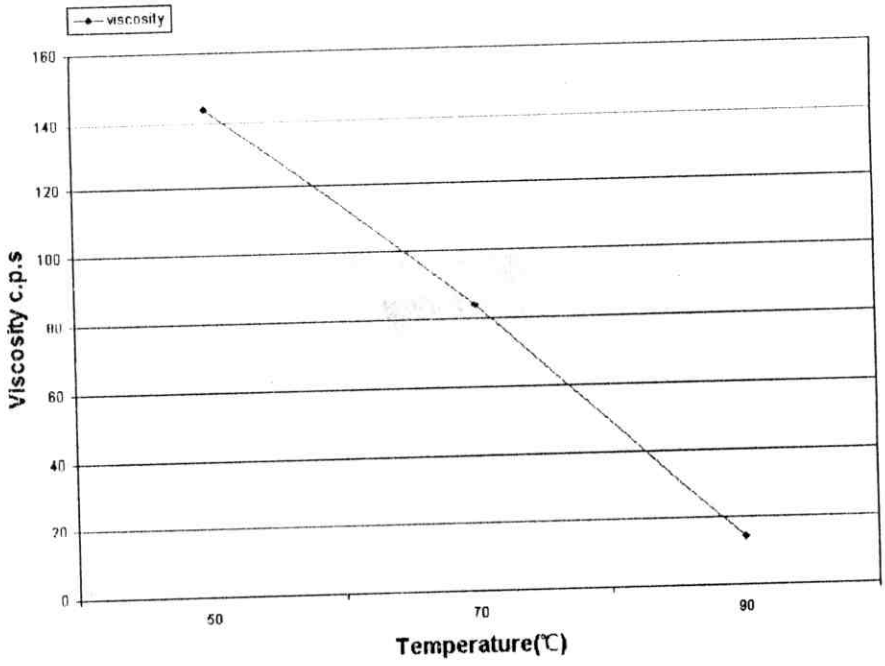
figure(11) solubility and swelling power of oxidized starch by hydrogen peroxide 3-1.



figure(12) viscosity of oxidized starch by hydrogen peroxide 3-1.



figure(13) solubility and swelling power of starch produced by hydrogen peroxide 3-2.



figure(16) viscosity of oxidized starch by sodium hypochlorite.

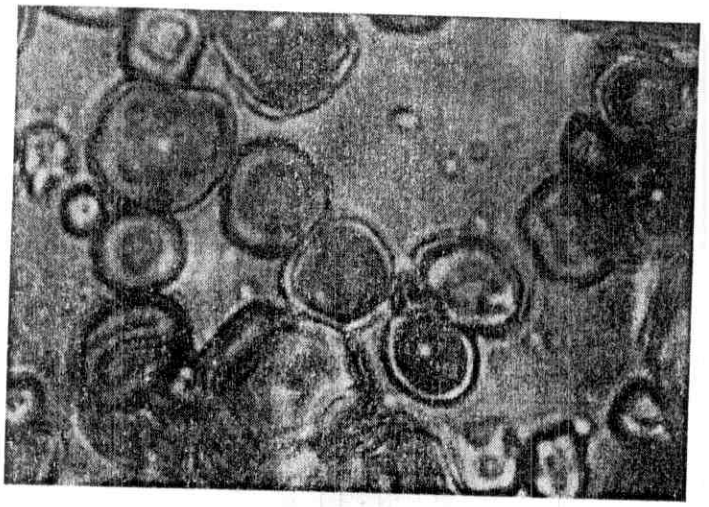
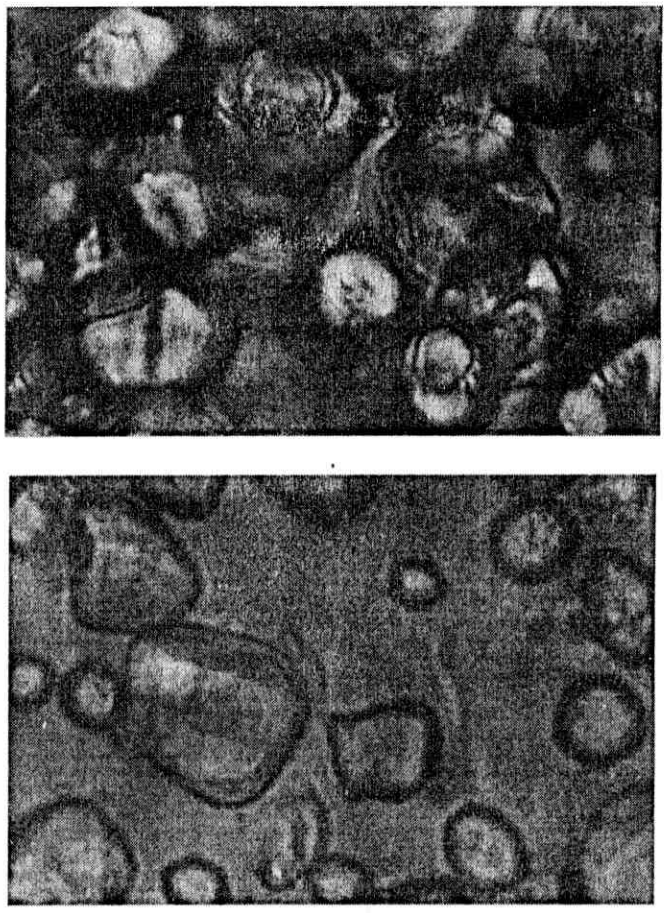


figure (17) native corn starch, polarized light
still birefringence
(the swelling behaviour, digestibility, paste viscosity and gel formation)



figure(20) oxidized starch, polarized light still birefringence.