Effect of different types of lipids and surfactants on starch properties in relation to their applications in food and industry

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Introduction

- **Starch**
  - Plant Origin – via Glucose synthesized during photosynthesis
  - Wide distribution- all vegetables, fruits, seeds and roots-especially in tuber crops
  - Energy source – easily digestible

Starch properties

- Granular size and shape
- Gelatinisation
- Viscosity
- Gel strength
- Stability of paste

Applications of starch

- Food
- Textile
- Paper
- Adhesive
- Sweetener
- Miscellaneous

Textile: Sizing, Finishing

Paper: Sizing, Printing, Craft paper

Adhesives:

- Simple Stationery adhesives
- Special adhesives
- Dextrins- White, yellow, British Gum

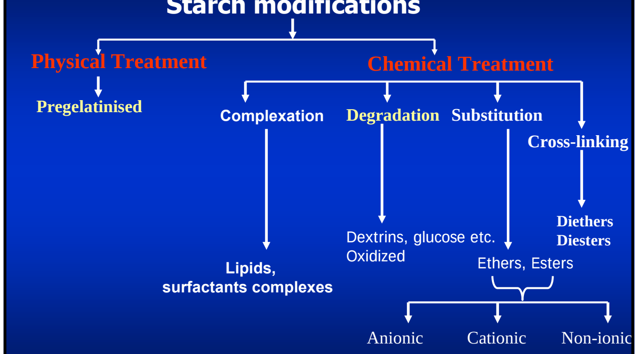
Sweeteners

- Liquid Glucose
- Dextrose
- Maltose
- High Fructose Syrups
- Sugar alcohols like Sorbitol, Maltitol, Erythritol etc.

Other special products and applications

- Ethanol
- Lactic and Citric acids
- Soaps and Detergents
- Explosives
- Horticultural mulches
- Oil drilling muds
- Tablets and capsules
- Concrete

Starch modifications



Applications of modified starches

Area	Modification	Functions
Paper	Cationic starch	Binding cationic charge
Corrugating	Pregelatinized	Binding/Glueing
Textile	Esters (Acetates)	Sizing/ Film formation
Coal briquetting	Esters	Binding Initial Tack
Adhesives	Esters	Adhesion / Quick drying
Oil well drilling	Esters/ ethers	Water binding/Thickening
Foundry	Pregelatinized starch	Binding/ Green Bond stability

Application of Starch in food

- Viscosity, Viscosity stability
- Paste clarity
- Cohesiveness of paste
- Swelling and solubility
- Gelatinization temperature
- Thermal stability
- pH stability

Tuber starches in food and industrial applications

- Cassava starch: high viscosity, good clarity, but poor viscosity stability and long cohesive texture for its paste
- Yam starch: high viscosity, stability and clarity
- Colocasia starch: small granules suitable in biodegradable plastics and toilet formulations, low but stable viscosity

In most applications starch is seldom used alone

- Salts, sugars, lipids and fibre affect starch properties
- Lipids and surfactants have strong interaction with starch
- Often Lipids and surfactants used to modify starch for various applications

Objectives:

To study the interaction of tuber starches with

- lipids of different chain length
- anionic, cationic and neutral surfactants using DSC, Viscography and iodimetry
- ow the effect can be put to use in food and industrial applications

Experimental

- Starches were extracted from fresh tubers harvested from CTCRI Farm
- Lysolecithin (C 6:0, C 10:0, C 14:0 and C 18:0): Sigma
- Cetyl trimethyl ammonium bromide, Sodium lauryl sulphate, Glyceryl Mono stearate, potassium stearate, potassium palmitate: AR grade, CDH, Bombay

Experimental…

- DSC –Seiko Instruments (Japan) with Modulation Facilifty
- Viscosity – Viscoamylograph (Brabender), RVA (Newport Scientific)
- Colorimetry- Pye unicam Spectrophotometer

Experimental…

- DSC - adding 1% lipid solution to 5 mg of starch in aluminum pans, sealing hermetically and with the following heating cycle

Heating: 30-130° at 2°min^{-1}
Cooling: 130-30° at 30°min^{-1}
Reheating: 30-130° at 2°min^{-1}
Cooling: to 30° at 30°min^{-1}

Modulation cycle of 3° heating and 2° cooling

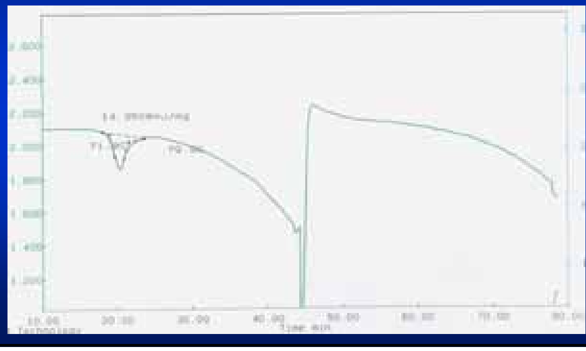
T_{onset}, T_{end}, Gel enthalpy (ΔH) obtained using built-in software

Experimental…

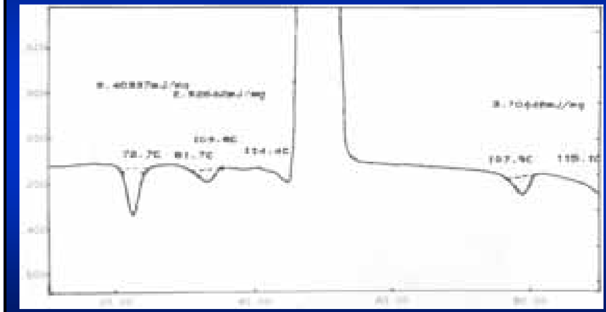
- Starch- surfactant complex prepared by mixing thoroughly starch with the surfactant in water, filtering and drying at room temperature
- The total and soluble amylose determined by standard iodimetric methods
- Viscosity determined for 3, 4 and 5% starch complexes in Brabender viscograph and 10% in RVA

Results and Discussion

Figure: DSC pattern of native starch (*D.rotundata*)



DSC patterns of starch-lipid complex



Effect of chain length of lysolecithin on gelatinisation temp. (°C)

Starch	C18 T_{init}	C18 T_{end}	C14 T_{end}	C14 T_{init}	C10 T_{init}	C10 T_{end}	C6 T_{init}	C6 T_{end}
Cassava I	64.3	76.5	65.4	77.4	63.4	76.0	64.3	77.5
II	106.0	114.8	93.7	103.4	-	-	-	-
III	108.7	116.4	98.2	104.9	73.5	81.0	-	-
Xantho. I	74.1	81.5	75.6	82.6	72.0	79.2	74.2	81.5
I	105.0	115.8	92.3	101.5	-	-	-	-
III	108.5	116.4	98.2	103.5	72.7	79.8	-	-
Col. I	79.5	86.9	79.5	86.6	77.2	85.1	-	-
II	104.2	112.5	95.1	102.0	-	-	-	-
III	108.0	115.4	99.5	105.2	80.2	87.3	-	-

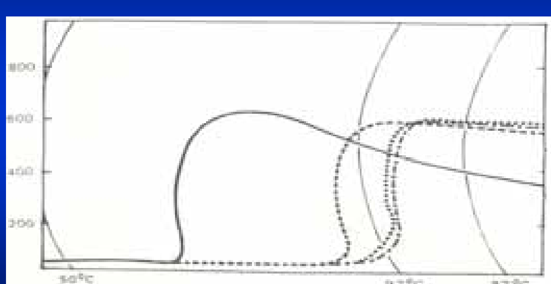
Effect of chain length of lysolecithin on gelatinisation enthalpy (Δ H j/g)

Starch	C18	C14	C10	C6
Cassava I	8.8	10.5	11.6	11.74
II	1.8	1.78	-	-
III	2.75	2.4	1.35	-
Xantho. I	9.3	11.38	12.8	13.1
II	3.0	2.3	-	-
III	3.75	2.82	1.86	-
Col. I	12.0	9.36	11.6	-
II	0.5	0.53	-	-
III	1.15	0.98	0.38	-

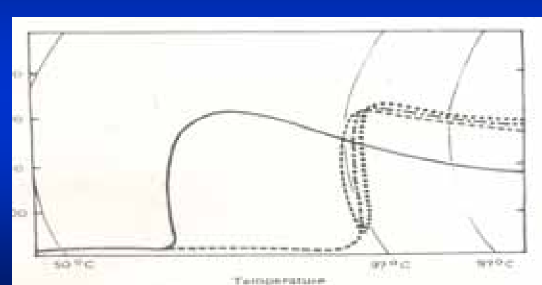
The effect of chain length on the thermal parameters

- Increase in chain length leads to enhanced melting temp for starch lipid complex
- For C6 system, no peak indicating that more than 6 carbon chain required for effective complexation
- Higher enthalpy with longer chains

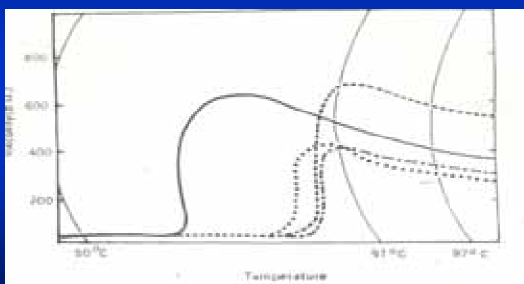
Viscosity pattern of starch-potassium stearate complex



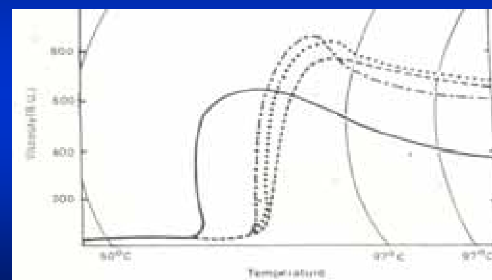
Viscosity pattern of starch-potassium palmitate complex



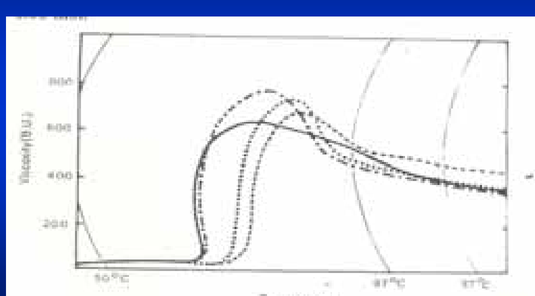
Viscosity pattern of starch-GMS complex



Viscosity pattern of starch-SLS complex



Viscosity pattern of starch-CTAB complex



Viscosity and gelatinisation temperatures of starch-surfactant complexes

Starch/ surfactant (mol/100gstarch)	Peak viscosity (BU)	Gel. temp °C
Starch	660	65-77
Starch+pot.st (0.02)	600	95-97
Starch+pot st(0.06)	600	97-
Starch+pot pal(0.02)	640	95-97
Starch+pot pal(0.06)	660	97-
Starch+GMS(0.02)	680	90-97
Starch+GMS(0.06)	420	94-97
Starch+SLS (0.02)	800	78-84
Starch+SLS (0.06)	900	77-83
Starch+CTAB (0.02)	680	73-85
Starch+CTAB (0.06)	780	68-80

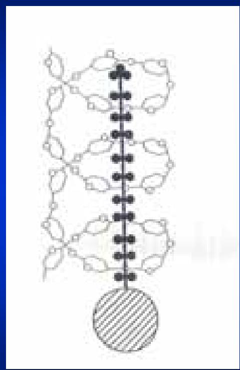
- Different surfactants have different effects on viscosity and swelling volumes
- Potassium stearate and palmitate lower the paste viscosity, but increase the stability viscosity
- Sodium lauryl sulphate increases peak viscosity but breakdown is also increased
- CTAB also enhances viscosity but not the viscosity stability

- Pasting temperature is enhanced considerably for potassium stearate and palmitate and GMS and slightly for GMS
- Swelling volumes are lowered for potassium sterate and palmitate and GMS, but increased for SLS and CTAB

Effect of cetyl trimethyl ammonium bromide on amylose content (Blue Values) of tuber starches

Starch	Total amylose	Soluble Amylose
Cassava	0.32	0.18
Cassava+CTAB	0.27	0.13
Colocasia	0.28	0.18
Colocasia+CTAB	0.20	0.07
D.esculenta	0.29	0.14
D.esculenta+CTAB	0.22	0.04
D.alata	0.43	0.18
D. alata+CTAB	0.38	0.11
D.rotundata	0.38	0.18
D.rotundtata+CTAB	0.35	0.12
Sweet potato	0.36	0.13
Sweet potato+CTAB	0.34	0.09
Xanthosoma	0.38	0.21
Xanthosoma+CTAB	0.33	0.15

- The data of amylose contents in the starches treated with CTAB shows that reduction in soluble amylose is more pronounced in Colocasia and D. *esculenta* starches
- The amylose molecules in these starches possess helical structure suitable for receiving the surfactant molecule



Conclusions

- Tuber starches can complex with lipids and surfactants and hence these can be incorporated to improve starch properties
- The lipids to be used to complex with starch should have longer methylene chains for effective complexation
- Lipids can be used to increase the gelatinisation temperaures where such property is required

Conclusions….

- Surfactants can be selected according to the properties required for the starch applications
- Potassium stearate and palmitate can be used to increase viscosity stability and pasting temperatures (Food, Frozen foods, Canned foods, textile and paper sizing)
- SLS can be useful in products requiring high viscosity (Certain foods, sizing of textiles, adhesives)
- CTAB can be useful in lowering soluble amylose and thereby cohesiveness in food and industrial applications