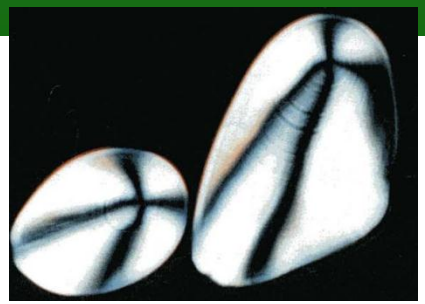
National Agriculture
and Food Research Organization

The enzymatic digestibility and phosphorus content in sweetpotato and potato starches



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NARO, JAPAN

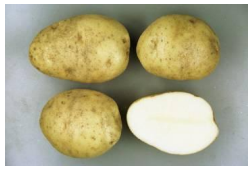
5th Korea-China-Japan Sweetpotato

17-19 September 2012, Jeju City, Korea.

Main tuber and root crops in Japan

Sweetpotato and potato are main starchy crops in Japan.

Sweetpotato and potato starches are produced in local factories.



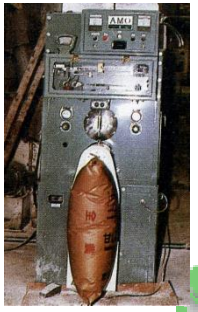
Konafubuki

Benimaru

Potato starch

Potato

Koganesengan



Sweetpotato starch

Shiroyutaka

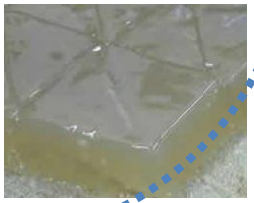
Tokyo

Sweetpotato

Products made from sweetpotato starch in Japan

Various noodles

“Kuzuko”



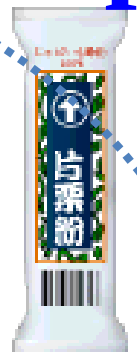
“Warabi-mochi”

Intact use (8000 t/year)

Saccharification products (52000 t/year)

Products made from potato starch in Japan

Various noodles



“Katakuriko”

“Kamaboko”
(boiled fish paste)

Intact use (120000 t/year)

Glucose-fructose syrup
(Isosyrup)

Saccharification products
(90000 t/year)

Potato starch has unique properties

1. The granule size of potato starch is definitely larger than other starches.
2. Potato starch has a wide distribution of granule size, ranging from 5 to 100μm.
3. Compared to other starches, potato starch has a higher phosphorus content.
4. Due to higher phosphorus content, potato starch exhibits extremely high viscosity.

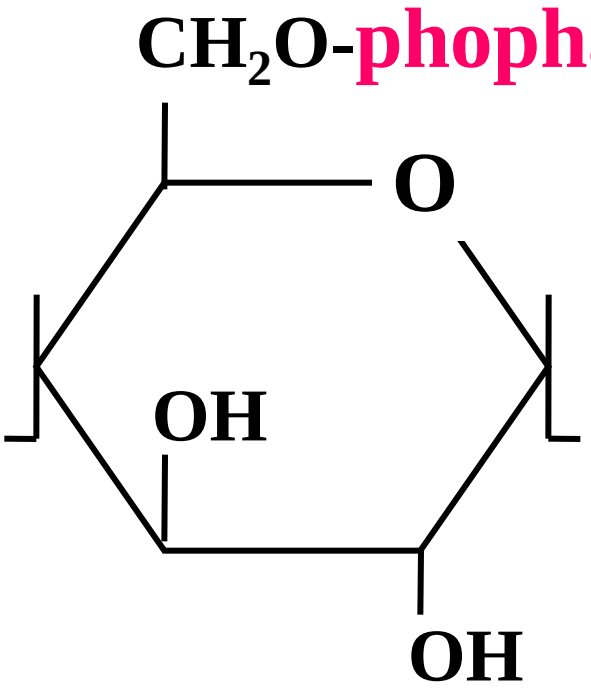
Granule size of root and tuber starches

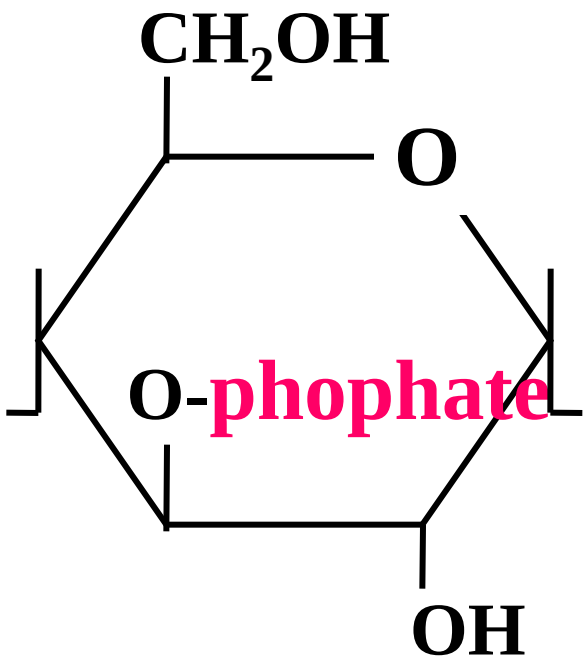
	Size distribution (μm)
Potato	15-110
Sweetpotato	2-42
Taro	3.0-3.5
Cassava	5-40
Kudu	3-23
Lotus	15-40

Large-sized

Hoover (2001) Carbohydr. Polym.

Starch bound phosphate(1)



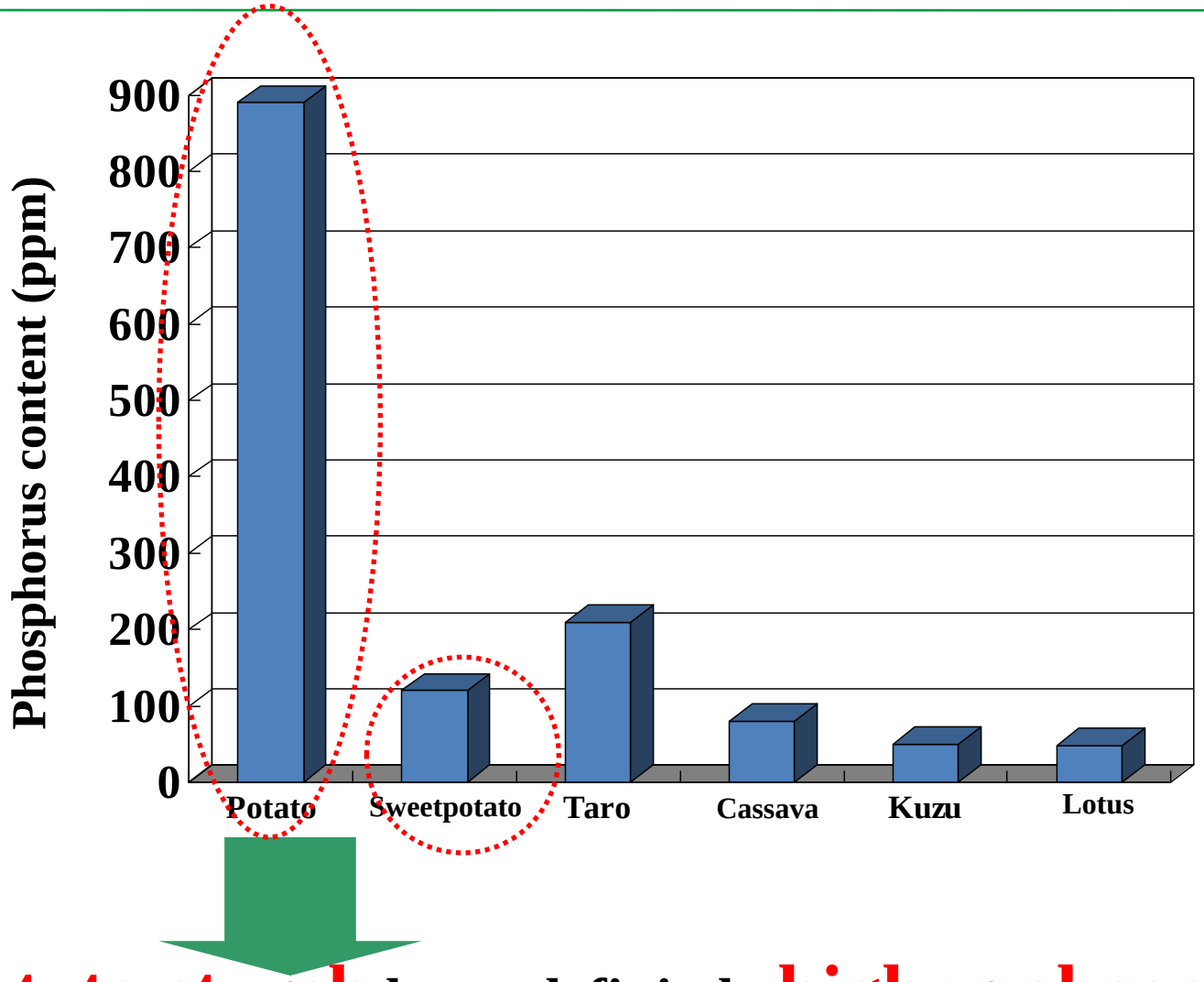


P at C-6 glucosyl residue

P at C-3 glucosyl residue

Starch bound phosphate exists in tuber starches.

Phosphorus content of root and tuber starches

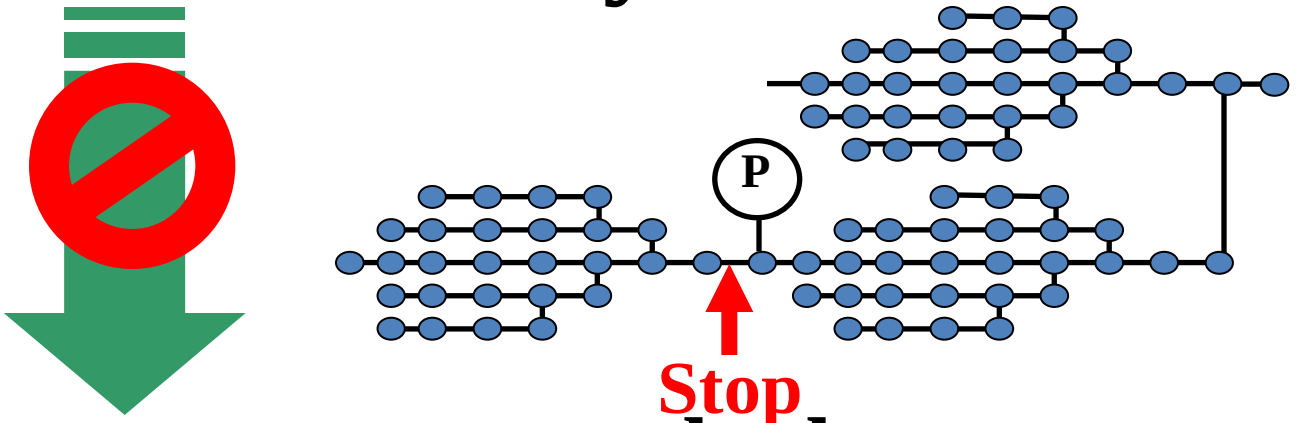


Potato starch has a definitely higher phosphorus content than other starches, such as sweetpotato starch.

Hoover (2001) *Carbohydr. Polym.*

Action of amylases on phosphorylated starch

Action of amylase



Phosphate groups attached to glucosyl residues of starch

Phosphorylated malto-oligosaccharides

Takeda et al. (1983) *Biochim. Biophys. Acta*

Kamasaka et al. (1995) *Biosci. Biotechnol. Biochem.*

Starch saccharification process

Starch

Add heat-stable bacterial alpha amylase

105 ℃, 5-7 min

90-100 ℃, 1- 2 hr

Maltodextrin

Phosphorylated malto-oligosacharides

Glucose

Add a fungal glucoamylase and a bacterial alpha-amylase

As starch is cooked for producing starch syrup, it is important to estimate the hydrolysis rate of gelatinized starch by industrial enzymes in the food industry.

Enzymatic digestibility is variable according to:

High amylose, large granule size

Low digestibility of raw starch

High phosphate

Low digestibility of raw and gelatinized starches

?

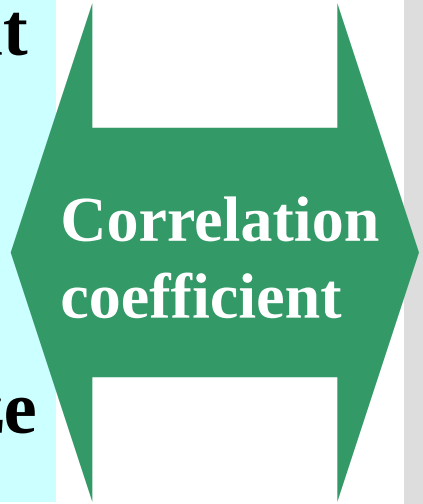
Till to-date, the experimental data on the digestibility of gelatinized starches are not available so much specially using many tuber and root starches.

Objective of this study

Phosphorus content

Amylose content

Meidan granule size



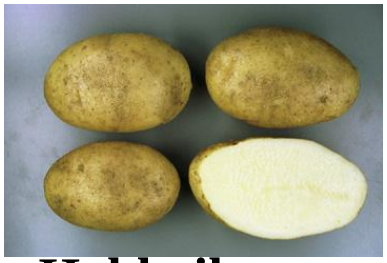
Enzyme digestibility
(after digestion of Termamyl 120L, *Bacillus* alpha-amylase, and glucoamylse)

Sweetpotato and potato starches and other tuber and root (cassava and yam) starches

To describe the effect of phosphorus and amylose contents and median granule size on the rate of gelatinized starch by industrial amylases

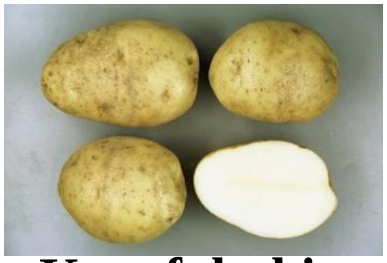
Materials (Starch)

1. Thirty-six potato starches



Hokkaikogane

Benimaru



Konafubuki

Shadow Queen

etc.

2. Four sweetpotato starches

Shiroyutaka

Ayamurasaki

etc.

3. Three cassava starches and one yam starch

Cassava

Yam

Methods(1)

1. Amylose content

- Blue value (680nm) method according to the equation of Takeda et al. (1983)

2. Mean granule size

- Using Sympatec HELOS Particle Size Analysis

3. Phosphorus content

- Vanado-Molybdate method

Amylose content and median granule size

	Amylose content (%)	Median granule size (µm)
Potato	15.4-25.5	14.0-44.7
Mean (n=36)	21.5	34.6
Sweetpotato	16.2-23.4	14.5-20.6
Mean (n=4)	19.6	17.0
Cassava	25.3-28.8	15.7-16.3
Mean (n=3)	26.5	16.1
Yam	25.8	22.8

Phosphorus content (ppm)

Potato Mean (n=36)	500-1132 760
Sweetpotato Mean (n=4)	156-231 192
Cassava Mean (n=3)	81-105 94
Yam	166

High-phosphorus, medium-phosphorus and low-phosphorus starches

On the basis of phosphorus content, we have arranged the experimental potato starches into two classes. Namely, there were 19 high-phosphorus starches (HPS) (812-1132 ppm) and 17 medium-phosphorus starches (MPS) (500-756 ppm).

We have defined sweetpotato, cassava and yam starches as low-phosphorus starches (LPS) as their phosphorus content ranged from 81 to 231 ppm.

Methods(2)

Starch was suspended in 49.5 ml of 6mM, 2mM $CaCl_2$ solution and 0.5% of Termamyl 120L Type L.

Heated to 100 ℃ to liquefy

Cool and incubate at 50 ℃ for 1 hr

Estimate the reducing sugar to calculate hydrolysis rate (1)

And then add *Bacillus* alpha-amylase

Incubate at 55 ℃ for 24 hrs

Estimate the reducing sugar to calculate hydrolysis rate (2)

And then add *Rhizopus* sp. glucoamylase

Incubate at 40 ℃ for 24 hrs

Estimate the reducing sugar to calculate hydrolysis rate (3)

Hydrolysis rate (%) after digestion of three amylases

	Termamyl 120L	Alpha-amylase	Glucoamylase
HPS (potato)	28-46	60-71	95-100
Mean (n=19)	35	65	97
MPS (potato)	35-48	64-74	97-100
Mean (n=17)	40	69	98
LPS (sweetpotato, cassava and yam)	35-48	64-72	99-100
Mean (n=8)	42	69	99

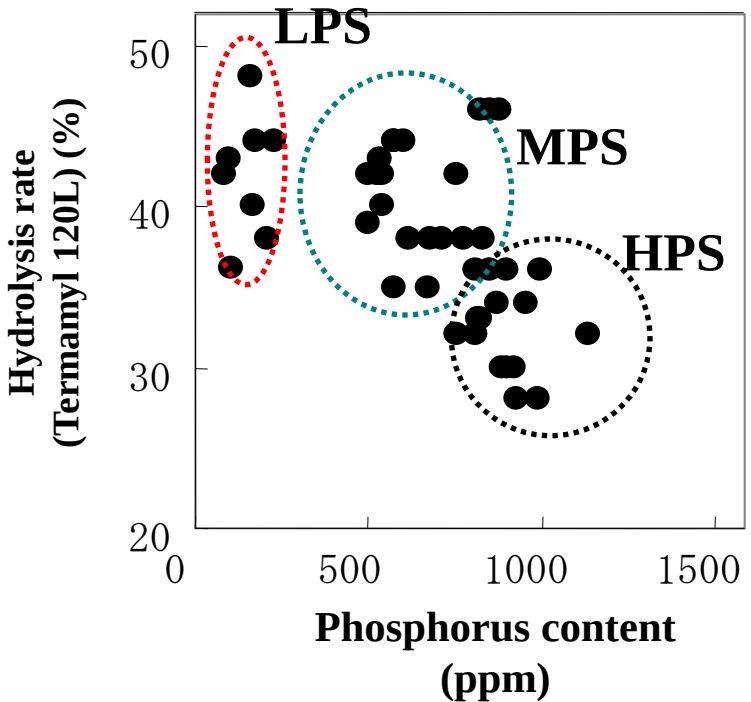
Low

High-phosphorus starches were more resistant to enzyme hydrolysis than middle- and low-phosphorus starches.

Correlation coefficients

Starch digestibility	Phosphorus content	Amylose content	Median granule size
Termamyl 120L	**-0.546****	0.171^{NS}	-0.170^{NS}
***Bacillus* alpha-amylase**	**-0.428****	0.251^{NS}	-0.104^{NS}
Glucoamylase	**-0.666****	0.385*	-0.276^{NS}

*** and ** Significant at the P≤0.05 and P≤0.01, respectively. NS :not significant.**



Higher phosphorus content is associated with lower hydrolysis rate by industrial amylases !!

Conclusion

1. High-phosphorus potato starches were more resistant to enzyme hydrolysis than middle-phosphorus potato starches as well as sweetpotato, cassava and yam starches.

2. The hydrolysis rate of tuber and root starches was not largely influenced by their amylose content and median granule size.

3. Information concerning the enzymatic digestion of gelatinized tuber and root starches might be important to the food industry.

Published report

Enzymatic hydrolysis of potato starches containing different amounts of phosphorus

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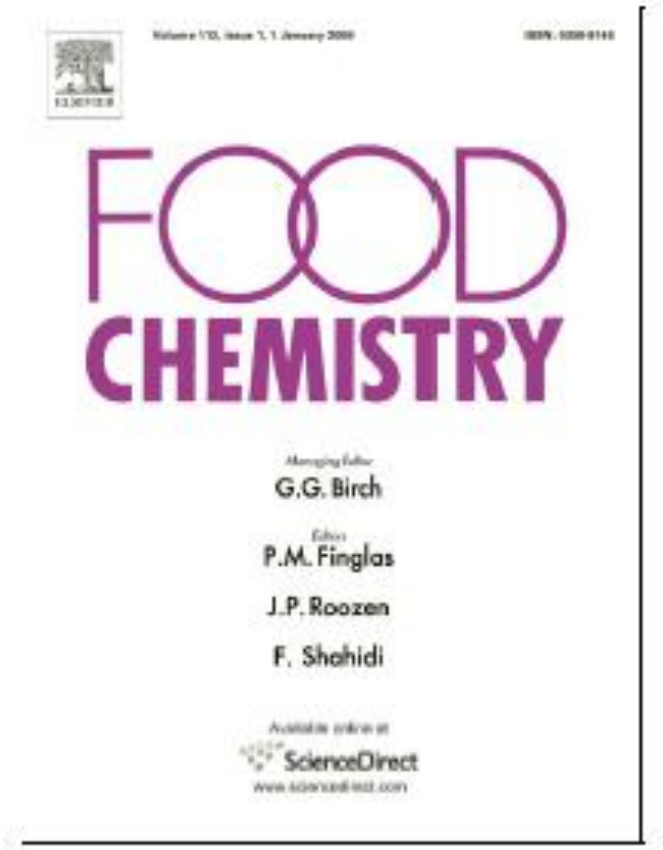

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Please refer to the above report, if you want to know the content of our today's talk in detail !

Thank you for your attention !!