# **IOP** Conference Series

# conferenceseries.iop.org

Physics • Materials science and engineering
 Earth and environmental science

# Quality, speed and flexibility

Open access conference proceedings





#### Pahasia IOP Conference Series: Earth and Environmental Science Table of contents Volume 147 2018 Previous issue Next issue > The 2nd International Conference on Agricultural Engineering for Sustainable Agricultural Production (AESAP 2017) 23-25 October 2017, Bogor, Indonesia View all abstracts Accepted papers received: 16 April 2018 Published online: 14 May 2018 Preface **OPEN ACCESS** 011001 The 2nd International Conference on Agricultural Engineering for Sustainable Agricultural Production (AESAP 2017) + View abstract View article PDF OPEN ACCESS 011002 Peer review statement + View abstract View article PDF Papers **Postharvest and Food Engineering OPEN ACCESS** 012001 Ultrasonic Technique for Predicting Grittiness of Salted Duck Egg S Erawan, I W Budiastra and I D M Subrata + View abstract View article PDF OPEN ACCESS 012002 Determination of the Internal Damage of Purple Sweet Potatoes Non-Destructively Using Ultrasonic Wave Characteristics Sutrisno and R M Fauzi PDF + View abstract View article **OPEN ACCESS** 012003 Visual Method for Detecting Contaminant on Dried Nutmeg Using Fluorescence Imaging S A Dahlan, U Ahmad and I D M Subrata View article PDF + View abstract

OPEN ACCESS Prediction of Caffe	ine Content in Java	a Preanger Coffee Beans by NIR Spectroscopy Using PLS and MLR Method	012004
I W Budiastra, Sutris			$\mathbf{O}_{\mathbf{A}}$
+ View abstract	View article		<u>S</u>
OPEN ACCESS	val Effect on the A	anurany of Image Dreamaning based Terrate Crading	012005
		ccuracy of Image Processing-based Tomato Grading	
	and story in story	, T Herwanto, M Saukat and W K Sugandi	
+ View abstract	View article	PDF	
OPEN ACCESS Mechanical Dama	ge Detection of Inc	donesia Local Citrus Based on Fluorescence Imaging	012006
T H Siregar, U Ahma			
+ View abstract	View article		
OPEN ACCESS	Sweet Potato's An	thocyanin as Biosensor for Detection of Chemicals in Food Products	012007
A Wulandari, TC Sun			
<ul> <li>Wulandari, TC Sun</li> <li>View abstract</li> </ul>	Iarti, F Fanma and E		
T VIEW ADSTRACT			
OPEN ACCESS	con Analycic Cuon	ing Test Arabica Coffee Using NIR Spectroscopy	012008
Safrizal, Sutrisno, P	weither and Barres Hotel		
+ View abstract	View article		
T view abstract			
			012009
	ti-layered Microca	psules from Nanofibrils of Soy Protein Isolate using Layer-by-Layer Adsorption Method	012009
Preparation of Mult			012009
Preparation of Mult N. Purwanti, Warji, S			012009
Preparation of Mult N. Purwanti, Warji, S + View abstract OPEN ACCESS	.S. Mardjan, S. Yulia	ni and K. Schroën	012009
Preparation of Mult N. Purwanti, Warji, S + View abstract OPEN ACCESS	.S. Mardjan, S. Yulia	ni and K. Schroën	
Preparation of Mult N. Purwanti, Warji, S + View abstract OPEN ACCESS The Classification of	.S. Mardjan, S. Yulia	ni and K. Schroën	
Preparation of Mult N. Purwanti, Warji, S + View abstract OPEN ACCESS The Classification of M Yulia, A R Asnanin	.S. Mardjan, S. Yulia	ni and K. Schroën	
Preparation of Mult N. Purwanti, Warji, S + View abstract OPEN ACCESS The Classification of M Yulia, A R Asnanin + View abstract OPEN ACCESS	.S. Mardjan, S. Yulia	ni and K. Schroen PDF Decaffeinated Coffee Using UV-VIS Spectroscopy and SIMCA Method PDF	
Preparation of Mult N. Purwanti, Warji, S + View abstract OPEN ACCESS The Classification of M Yulia, A R Asnanin + View abstract OPEN ACCESS The Detection and	S. Mardjan, S. Yulia View article of Ground Roasted g and D Suhandy View article Quantification of A	ni and K. Schroën PDF Decaffeinated Coffee Using UV-VIS Spectroscopy and SIMCA Method	012010
Preparation of Mult N. Purwanti, Warji, S + View abstract OPEN ACCESS The Classification of M Yulia, A R Asnanin + View abstract OPEN ACCESS The Detection and Tandem with Chem	S. Mardjan, S. Yulia View article of Ground Roasted og and D Suhandy View article Quantification of A nometrics	Ini and K. Schroen PDF Decaffeinated Coffee Using UV-VIS Spectroscopy and SIMCA Method PDF Adulteration in Ground Roasted Asian Palm Civet Coffee Using Near-Infrared Spectroscopy in	012010
Preparation of Mult N. Purwanti, Warji, S + View abstract OPEN ACCESS The Classification of M Yulia, A R Asnanin + View abstract OPEN ACCESS The Detection and Tandem with Chem D Suhandy, M Yulia,	S. Mardjan, S. Yulia View article of Ground Roasted og and D Suhandy View article Quantification of A nometrics	Ini and K. Schroen PDF Decaffeinated Coffee Using UV-VIS Spectroscopy and SIMCA Method PDF Adulteration in Ground Roasted Asian Palm Civet Coffee Using Near-Infrared Spectroscopy in	012010
Preparation of Mult N. Purwanti, Warji, S + View abstract OPEN ACCESS The Classification of M Yulia, A R Asnanin + View abstract OPEN ACCESS The Detection and Tandem with Chem D Suhandy, M Yulia, + View abstract	S. Mardjan, S. Yulia View article of Ground Roasted ag and D Suhandy View article Quantification of A nometrics Y Ogawa and N Kon	Ini and K. Schroen PDF Decaffeinated Coffee Using UV-VIS Spectroscopy and SIMCA Method PDF Adulteration in Ground Roasted Asian Palm Civet Coffee Using Near-Infrared Spectroscopy in do	012010
Preparation of Mult N. Purwanti, Warji, S + View abstract OPEN ACCESS The Classification of M Yulia, A R Asnanin + View abstract OPEN ACCESS The Detection and Tandem with Chem D Suhandy, M Yulia, + View abstract OPEN ACCESS	S. Mardjan, S. Yulia View article of Ground Roasted ag and D Suhandy View article Quantification of A nometrics Y Ogawa and N Kon	Ini and K. Schroen PDF Decaffeinated Coffee Using UV-VIS Spectroscopy and SIMCA Method PDF Adulteration in Ground Roasted Asian Palm Civet Coffee Using Near-Infrared Spectroscopy in do	012010
Preparation of Mult N. Purwanti, Warji, S + View abstract OPEN ACCESS The Classification of M Yulia, A R Asnanin + View abstract OPEN ACCESS The Detection and Tandem with Chem D Suhandy, M Yulia, + View abstract OPEN ACCESS Optimization of Ste	S. Mardjan, S. Yulia View article of Ground Roasted ag and D Suhandy View article Quantification of A nometrics Y Ogawa and N Kon View article aamed Meals Base	ni and K. Schroen PDF Decaffeinated Coffee Using UV-VIS Spectroscopy and SIMCA Method PDF Adulteration in Ground Roasted Asian Palm Civet Coffee Using Near-Infrared Spectroscopy in do PDF	012010
Preparation of Mult N. Purwanti, Warji, S + View abstract OPEN ACCESS The Classification of M Yulia, A R Asnanin + View abstract OPEN ACCESS The Detection and Tandem with Chem D Suhandy, M Yulia, + View abstract OPEN ACCESS Optimization of Ster Sunarmani, Setyadjit	S. Mardjan, S. Yulia View article of Ground Roasted ag and D Suhandy View article Quantification of A nometrics Y Ogawa and N Kon View article aamed Meals Base	ni and K. Schroen PDF Decaffeinated Coffee Using UV-VIS Spectroscopy and SIMCA Method PDF Adulteration in Ground Roasted Asian Palm Civet Coffee Using Near-Infrared Spectroscopy in do PDF	012010
Preparation of Mult N. Purwanti, Warji, S + View abstract OPEN ACCESS The Classification of M Yulia, A R Asnanin + View abstract OPEN ACCESS The Detection and Tandem with Chem D Suhandy, M Yulia, + View abstract OPEN ACCESS Optimization of Ste Sunarmani, Setyadjit + View abstract OPEN ACCESS Determination of the	.S. Mardjan, S. Yulia View article of Ground Roasted ag and D Suhandy View article Quantification of A ometrics Y Ogawa and N Kon View article eamed Meals Base t and S Ermi View article t and S Ermi	ni and K. Schroen PDF I Decaffeinated Coffee Using UV-VIS Spectroscopy and SIMCA Method PDF Adulteration in Ground Roasted Asian Palm Civet Coffee Using Near-Infrared Spectroscopy in do PDF ed on Composite Flour (Taro, Banana, Green Bean) and Its Predicted Shelf Life	012010
Preparation of Mult N. Purwanti, Warji, S + View abstract OPEN ACCESS The Classification of M Yulia, A R Asnanin + View abstract OPEN ACCESS The Detection and Tandem with Chem D Suhandy, M Yulia, + View abstract OPEN ACCESS Optimization of Ste Sunarmani, Setyadjit + View abstract OPEN ACCESS Determination of th from Different Origi	S. Mardjan, S. Yulia View article of Ground Roasted ag and D Suhandy View article Quantification of A nometrics Y Ogawa and N Kon View article amed Meals Base t and S Ermi View article t and S Ermi View article t and S Ermi	Ini and K. Schroen PDF Decaffeinated Coffee Using UV-VIS Spectroscopy and SIMCA Method PDF Adulteration in Ground Roasted Asian Palm Civet Coffee Using Near-Infrared Spectroscopy in do PDF ed on Composite Flour (Taro, Banana, Green Bean) and Its Predicted Shelf Life PDF and Classification of Near-Infrared Spectra of Patchouli Oil ( <i>Pogostemon Cablin Benth.</i> )	012010 012011 012012
N. Purwanti, Warji, S + View abstract OPEN ACCESS The Classification of M Yulia, A R Asnanin + View abstract OPEN ACCESS The Detection and Tandem with Chem D Suhandy, M Yulia, + View abstract OPEN ACCESS Optimization of Ster Sunarmani, Setyadjit + View abstract OPEN ACCESS	S. Mardjan, S. Yulia View article of Ground Roasted ag and D Suhandy View article Quantification of A nometrics Y Ogawa and N Kon View article amed Meals Base t and S Ermi View article t and S Ermi View article t and S Ermi	Ini and K. Schroen PDF Decaffeinated Coffee Using UV-VIS Spectroscopy and SIMCA Method PDF Adulteration in Ground Roasted Asian Palm Civet Coffee Using Near-Infrared Spectroscopy in do PDF ed on Composite Flour (Taro, Banana, Green Bean) and Its Predicted Shelf Life PDF and Classification of Near-Infrared Spectra of Patchouli Oil ( <i>Pogostemon Cablin Benth.</i> )	012010 012011 012012
Preparation of Mult N. Purwanti, Warji, S + View abstract OPEN ACCESS The Classification of M Yulia, A R Asnanin + View abstract OPEN ACCESS The Detection and Tandem with Chem D Suhandy, M Yulia, + View abstract OPEN ACCESS Optimization of Ste Sunarmani, Setyadjit + View abstract OPEN ACCESS Determination of th from Different Origi M C R Diego, Y A Pur + View abstract	S. Mardjan, S. Yulia View article of Ground Roasted ag and D Suhandy View article Quantification of A nometrics Y Ogawa and N Kon View article admed Meals Base t and S Ermi View article t and S Ermi View article t and S Ermi View article t and S Ermi	Ini and K. Schroen PDF Decaffeinated Coffee Using UV-VIS Spectroscopy and SIMCA Method PDF Adulteration in Ground Roasted Asian Palm Civet Coffee Using Near-Infrared Spectroscopy in do PDF ed on Composite Flour (Taro, Banana, Green Bean) and Its Predicted Shelf Life PDF and Classification of Near-Infrared Spectra of Patchouli Oil ( <i>Pogostemon Cablin Benth.</i> ) I W Budiastra	012010 012011 012012
Preparation of Mult N. Purwanti, Warji, S + View abstract OPEN ACCESS The Classification of M Yulia, A R Asnanin + View abstract OPEN ACCESS The Detection and Tandem with Chem D Suhandy, M Yulia, + View abstract OPEN ACCESS Optimization of Ste Sunarmani, Setyadjit + View abstract OPEN ACCESS Determination of the from Different Origi M C R Diego, Y A Pur + View abstract OPEN ACCESS	S. Mardjan, S. Yulia View article of Ground Roasted ag and D Suhandy View article Quantification of A nometrics Y Ogawa and N Kon View article at and S Ermi View article t and S Ermi View article te Characteristics a in wanto, Sutrisno and View article	Ini and K. Schroën PDF Decaffeinated Coffee Using UV-VIS Spectroscopy and SIMCA Method PDF Adulteration in Ground Roasted Asian Palm Civet Coffee Using Near-Infrared Spectroscopy in do PDF ed on Composite Flour (Taro, Banana, Green Bean) and Its Predicted Shelf Life PDF and Classification of Near-Infrared Spectra of Patchouli Oil ( <i>Pogostemon Cablin Benth.</i> ) I W Budiastra	012010 012011 012012

			5.
OPEN ACCESS			012015
Application of Co	ld Storage for Raja	Sere Banana ( <i>Musa acuminata colla</i> )	
S R S Crismas, Y A	Purwanto and Sutrisi	no	·O_
+ View abstract	View article	🔁 PDF	S.
OPEN ACCESS			012016
Effect of Agitation	n in Alkalization Pro	cess on the Characteristics of Sodium Carboxymethyl Sago and Cassava Starches	
C S Titi, R Fachrudi	in, E Ruriani and I Yul	iasih	
+ View abstract	View article	PDF	
OPEN ACCESS			012017
		sotherm by DVS Hydrosorb	
416 010001-01-01000000000-1- 0-0-00	Purwanto, N Purwan		
+ View abstract	View article	PDF	
Agricultural Mac	chinery		
OPEN ACCESS			012018
Liquid Fertilizer S	praying Performanc	e Using A Knapsack Power Sprayer On Soybean Field	
P Gatot and R Anai	ng		
+ View abstract	View article	🔁 PDF	
OPEN ACCESS			012019
Conceptual Desi	gn of Fertilizer Appli	cator for Oil Palm on Terrace Cultivation	
W Hermawan			
+ View abstract	View article	PDF	
OPEN ACCESS			012020
allera a second	Research Conservation	Control Characteristic of Rice Combine Harvester Model	
the second s	Setiawan, I D M Subr	American States	
+ View abstract	View article	PDF	
OPEN ACCESS	mio Approach to D	eside on Optimal Manneyer and Machanization in Disc Deschustion	012021
		esign an Optimal Manpower and Mechanization in Rice Production	
Muanah, M F Syua			
+ View abstract	View article	PDF	
OPEN ACCESS		Mines for Dural Final Foreign	012022
		I Mixer for Dual Fuel Diesel Engine	
Desrial, W Saputro			
+ View abstract	View article	PDF	

#### **PAPER • OPEN ACCESS**

## The 2nd International Conference on Agricultural Engineering for Sustainable Agricultural Production (AESAP 2017)

To cite this article: 2018 IOP Conf. Ser.: Earth Environ. Sci. 147 011001

View the article online for updates and enhancements.

#### **Related content**

- Rasi-- Towards sustainable agricultural production: Growth and production of three varieties of shallot with some various Nitrobacter bio-fertilizer concentrations Saharuddin, N E Dungga, E Syam'un et al.
- International Conference on Biomass: Technology, Application, and Sustainable Development
- International Conference on Compressors and their Systems

IOP Conf. Series: Earth and Environmental Science 147 (2018) 011001 doi:10.1088/1755-1315/147/1/011001

#### Preface

Proceedings of AESAP 2017 contains papers presented in technical session of the 2<sup>nd</sup> International Conference on Agricultural Engineering for Sustainable Agriculture Production, held at Bogor Agricultural University (IPB) in 23-25 October 2017.

This proceedings consists of 48 papers presented in the technical session of the conference. The papers cover a broad area in Agricultural Engineering. The papers discuss the topics in postharvest and food engineering, energy and environment, land and water resources engineering, system and management in agriculture, instrumentation and monitoring system, and agricultural machinery.

We would like to thank all authors for their efforts in preparing their papers. A great appreciation is also given to the reviewers for their assistance in reviewing the manuscripts. Special thanks to secretariat members for their assistance in formatting the layout of the proceedings.

Dr Desrial Chairman of AESAP 2017

**IOP** Publishing

SIG

AESAP 2017

IOP Conf. Series: Earth and Environmental Science 147 (2018) 011001



S/G

#### **Editors**

Dr. Leopold Oscar Nelwan (COORDINATOR) Department of Mechanical and Biosystem Engineering Faculty of Agricultural Engineering and Technology Bogor Agricultural University, Indonesia <u>lonelwan@yahoo.com</u>

Dr. Usman Ahmad Department of Mechanical and Biosystem Engineering Faculty of Agricultural Engineering and Technology

Bogor Agricultural University, Indonesia

Dr. Slamet Widodo

Department of Mechanical and Biosystem Engineering Faculty of Agricultural Engineering and Technology Bogor Agricultural University, Indonesia

Dr. I Wayan Astika Department of Mechanical and Biosystem Engineering Faculty of Agricultural Engineering and Technology Bogor Agricultural University, Indonesia

Dr. Anisur Rahman Postdoctoral Research Associate Department of Biosystems Machinery Engineering Chungnam National University, South Korea <u>anis@cnu.ac.kr</u>

Dr. Shinichiro Kuroki Assistant Professor Department of Agricultural Engineering and Socio-Economics Kobe University, Japan <u>skuroki@dragon.kobe-u.ac.jp</u>

Dr. Wan Nor Zanariah Binti Zainol @ Abdullah Senior Lecturer Faculty of Agriculture and Food Sciences Universitas Putra Malaysia, Malaysia wnzz@upm.edu.my doi:10.1088/1755-1315/147/1/011001

IOP Conf. Series: Earth and Environmental Science 147 (2018) 011001 doi:10



SIQ



Hosted By:



DEPARTMENT OF MECHANICAL AND BIOSYSTEM ENGINEERING FACULTY OF AGRICULTURAL ENGINEERING AND TECHOLOGY BOGOR AGRICULTURAL UNIVERSITY



Sponsored By:





#### **PAPER • OPEN ACCESS**

### Peer review statement

To cite this article: 2018 IOP Conf. Ser.: Earth Environ. Sci. 147 011002

View the article online for updates and enhancements.

#### **Related content**

Naria Naria - Peer review statement

- Peer review statement

- Peer review statement



IOP Conf. Series: Earth and Environmental Science **147** (2018) 011002

### **Peer review statement**

All papers published in this volume of *IOP Conference Series: Earth and Environmental Science* have been peer reviewed through processes administered by the proceedings Editors. Reviews were conducted by expert referees to the professional and scientific standards expected of a proceedings journal published by IOP Publishing.

#### PAPER • OPEN ACCESS

## Effect of Agitation in Alkalization Process on the Characteristics of Sodium Carboxymethyl Sago and Cassava Starches

To cite this article: C S Titi et al 2018 IOP Conf. Ser.: Earth Environ. Sci. 147 012016

View the article online for updates and enhancements.

#### **Related content**

 Removal of total suspended solid by natural coagulant derived from cassava peel waste
 S Mohd-Asharuddin, N Othman, N S Mohd-Zin et al.

Jasi-

- Effect of Agitation on Acidogenesis Stage of Two-Stage Anaerobic Digestion of Palm Oil Mill Effluent (POME) into Biogas
   B Trisakti, Irvan, H Adipasah et al.
- <u>Nanofibrous membranes from aqueous</u> electrospinning of carboxymethyl chitosan Jian Du and You-Lo Hsieh



# IOP ebooks<sup>™</sup>

Bringing you innovative digital publishing with leading voices to create your essential collection of books in STEM research.

Start exploring the collection - download the first chapter of every title for free.

IOP Conf. Series: Earth and Environmental Science 147 (2018) 012016 doi:10.1088/1755-1315/147/1/012016

IOP Publishing

No.

# **Effect of Agitation in Alkalization Process on the Characteristics of Sodium Carboxymethyl Sago and Cassava Starches**

Titi C S<sup>1</sup>, R Fachrudin<sup>1</sup>, E Ruriani<sup>1</sup> and I Yuliasih<sup>1</sup>

<sup>1</sup>Department of Agroindustrial Technology, Bogor Agricultural University, Bogor, Indonesia

E-mail: titi-cs@apps.ipb.ac.id

Abstract. Sodium carboxymethyl starch (Sodium CMS) is a modified starch prepared by two successive processes, alkalization and etherification. Alkalization will change the activated hydroxyl group of starch to more reactive alkoxide (St-O<sup>-</sup>), and then carboxymethyl group will substitute the hydroxyl group into sodium CMS. This research investigated the effect of agitation (1000 rpm of stirring and 4000 rpm of homogenization) in alkalization process to the modification of native starch into sodium CMS. Cassava and sago starches were mixed with sodium hydroxide (1.8 and 1.9 moles per mole anhydrous glucose units). The combination of NaOH and homogenizing gave the highest degrees of substitution for cassava (DS 0.73) and sago (DS 0.55) starches. The sodium CMS characteristics (paste clarity, water and oil absorption capacities, solubility, swelling power) were a function of mixing method but not on the amount of NaOH used.

#### 1. Introduction

Starch is one of natural polymers that has been used in food and non-food applications. However, the utilization of native starch is limited in physical and chemical properties, since it is insoluble in cold water, easily degraded in high temperature, has low paste clarity and low stability. A common way to overcome these weaknesses is to modify the molecular structure of starch by physical, chemical, and or a combination of both treatments, which will improve the properties of native starch [1]. Modification of starch can be carried out by cleavage the molecular structure, rearranging the molecular structure, oxidation or substitution of the chemical group on the starch molecule [2], changing the chemical structure through D-glucopyranosyl starch linkage which consists of anhydrous glucose units (AGU). Carboxymethylation is one method of modification by substitution of the starch molecule, which produces starch with low gelatinization temperature, high solubility, and high shelf life. The carboxymethylation process takes place by substituting the native starch hydroxyl group (-OH) with the carboxymethyl group (CH<sub>2</sub>COO-) to produce Na-carboxymethyl or carboxymethyl starch (CMS)[3]. The utilization of Na-carboxymethyl starch is used as a disintegrant in the pharmaceutical industry [4] as well as sizing and printing agent in the textile industry [5-6].

Carboxymethylation takes place through two stages, namely alkalization and etherification. The Nacarboxymethyl starch can be produced by the reaction between native starch and sodium monochloroacetate (SMCA) by induction of NaOH [7]. Alkalization stage uses a strong base which converts an activated starch hydroxyl group and transforms it into a more reactive form of alkoxide (St-O-) [3]. The

Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI. Published under licence by IOP Publishing Ltd 1

IOP Conf. Series: Earth and Environmental Science 147 (2018) 012016 doi:10.1088/1755-1315/147/1/012016

**IOP** Publishing

etherification process is conducted in the second stage by substituting the carboxymethyl group of SMCA with alkoxide and producing Na-carboxymethyl starch.

The formation of Na-carboxymethyl starch can be detected through the degrees of substitution (DS) produced. Factors that affect the production of Na-carboxymethyl starch include starch type, NaOH, and SMCA concentration. The alkalization stage also influences Na-carboxymethyl starch production. Agitation at this stage will determine the effectiveness of alkalization to activate the starch carboxyl group. Hasanudin [8] states that more collisions between molecules of a substance will cause the reaction to take place more quickly. Mixing can also expand the contact area so as to increase the chance of collisions between molecules. Each type of agitation will produce different reaction rates. Studies on the optimum concentrations of NaOH and SMCA have been conducted previously [3]. The type of starch used will influence the different characteristics of Na-carboxymethyl starch [3, 9].

This study aims to investigate the effect of agitation and mixing (stirring and homogenization) in the alkalization stage and the concentration of NaOH used on the characteristics of the Na-carboxymethyl starch produced from sago and cassava starches.

#### 2. Materials and method

#### 2.1. Production of Na-Carboxymethyl Starch

Production of Na-carboxymethyl starch is carried out based on Ref. [3] with slight modifications. The process was divided into two successive processes, alkalization and etherification (carboxymethylation).

2.1.1. Alkalization process. Cassava and sago starch were obtained from small industries in Bogor. Starch was dried and sieved to pass 100 mesh, and its moisture content determined for calculating the number of chemicals used in the reaction. About 50 g of starch is suspended in isopropanol with starch ratio: isopropanol 1:14 (w: v). Two types of agitation were used in this experiment, (1) hot magnetic stirrer with 4 cm magnetic bar and agitation speed of 1000 rpm and (2) Ultra Turrax homogenizer with 4 cm of rotor diameter and agitation speed of 4000 rpm. The suspension was then added NaOH at a ratio of 1.8 - 1.9 moles/mole of AGU (anhydroglucose unit) and mixed for 20 minutes at 40°C. Viscosity and density of each mixture was measured for determining the Reynold number of fluids

2.1.2. Carboxymethylation Process. The reactor used consists of a three-neck flask with reflux. Sodium monochloroacetate (SMCA) was added with a ratio of 1.5 moles/mole AGU. Continous stirring at 250 rpm was continued for 3 hours after the addition of SMCA with the reaction temperature kept constant at 40°C. After the mixing process, the pH value of the medium was set in the range pH 5.5 - 6.5 by adding 50% HCl solution to stop the substitution reaction process. The formed Na-carboxymethyl starch was washed with 85% ethanol and filtered until the filtrate gave a negative response to the silver nitrate solution indicative of the absence of SMCA. The Na-carboxymethyl starch is then dried with oven at  $60^{\circ}$ C.

#### 2.2. Characterization of Na-Carboxymethyl Starch

Etherification parameters; the degree of substitution (DS) and reaction efficiency (RE) were determined according to ISO 11216-1998 method [10]. Characterization of Na-carboxymethyl starch solubility and swelling power, water and oil absorption capacities, and 1 % paste clarity at 650 nm were conducted with slight modification [11].

#### 3. Results and discussion

The starch used in this study has amylose content of 25.12% for sago and 19.15% for cassava. Ref. [14] states that sago starch contains 27% amylose and 73% amylopectin, whereas according to Ref. [15], cassava amylose component was 17% and 83% amylopectin, which is in reasonable agreement with our findings. The amylose and amylopectin ratio will affect the characteristics of the Na-carboxymethyl

AESAP 2017

IOP Conf. Series: Earth and Environmental Science 147 (2018) 012016 doi:10.1088/1755-1315/147/1/012016

IOP Publishing

starch formed. Amylose tends to be easier to swell when compared with amylopectin and this helps the distribution of chemical compounds into starch granules.

#### 3.1. Agitation and flow pattern in alkalization process

The first step is alkalizing with NaOH as a promoter; therewith producing alkaline starch. Isopropanol serves as a reaction medium and will dissolve minor components such as fiber, ash, fat, and protein. The alkalization step is an opening step for activating the starch hydroxyl group (St-OH) into a negatively charged alkoxide group [3]. Repulsive force of the negative charge will make the starch granules swell [16] thus facilitating diffusion of chemicals into the starch granules [3].

Swelling is rarely a spontaneous process, and requires the input of energy, usually supplied by mechanical shear provided by various types of mixers; in this research, a magnetic stirrer and rotor-stator homogenizer are used. It is important to match the agitator and agitation condition to the characteristics of product; therefore, dimensionless analysis is used, as described in table 1. Cassava starch produced higher viscosity and swelling capability compared to sago starch, as well as low density of mixture. It is expected that these properties will be beneficial in the etherification process [17].

<b>Table 1.</b> Effects of agitation types and starch mixture to the Reynolds Number $(N_{Re})$					
Type of	Viscosity	Density	Ø impeller (m)	Speed	N <sub>Re</sub>
agitation	(Pa.s)	$(kg/m^3)$		(rpm)	Ke
Cassava Starch					
Stirring	0.12	857.35	0.04	1 000	11 431
Homogenizing	0.12	857.35	0.04	4 000	45 725
Sago Starch					
Stirring	0.02	876.05	0.04	1 000	70 084
Homogenizing	0.02	876.05	0.04	4 000	280 336

The results of  $N_{Re}$  calculation (table 1) for each type of stirring or agitation using both cassava and sago starch indicate a Reynolds number over 4000, which is indicative of turbulent flow [18] that is stronger in the homogenizer than in the magnetic stirrer.

#### 3.2. Characteristics of Na-Carboxymethyl Starch

The alkalization stage weakens the alpha-helix in starch and breaks down the crystalline structure [16], which can facilitate solvent and SMCA entering the starch granules and substituting the alkoxide group with the carboxymethyl group from SMCA [17].

Table 2. Substitution parameters for carboxymethyl starch production					
	Magnetic	Stirring	Homogenizing		
Parameter	Moles of NaOH per mole AGU				
	1.8	1.9	1.8	1.9	
Cassava Starch					
Degree of substitution	$0.50 \pm 0.02^{a}$	$0.53 \pm 0.01^{a}$	$0.79 \pm 0.02^{b}$	$0.82{\pm}0.03^{b}$	
Reaction Efficiency (%)	33.27±1.39ª	35.53±0.68ª	52.56±1.55 <sup>b</sup>	$54.70 \pm 1.94^{b}$	
Sago Starch					
Degree of substitution	$0.54 \pm 0.02^{a}$	$0.55 \pm 0.02^{a}$	$0.70 \pm 0.01^{b}$	$0.73 \pm 0.02^{b}$	
Reaction Efficiency (%)	35.90±1.63ª	$36.93 \pm 1.60^{a}$	$47.18 \pm 0.97^{b}$	$48.60 \pm 1.06^{b}$	

\*Means within a row related to particular parameter with the same superscript letter are not significantly different as  $\alpha$ =0.05 confidence level.

IOP Conf. Series: Earth and Environmental Science 147 (2018) 012016 doi:10.1088/1755-1315/147/1/012016

IOP Publishing

3.2.1. The degree of Substitution and Reaction Efficiency. The degree of substitution (DS) is the average number of substituents per anhydroglucose unit (AGU). Each AGU contains three hydroxyl groups, therefore the maximum DS value obtainable is 3. The degree of substitution in carboxymethylation of starch is defined as the average number of starchy hydroxyl groups substituted by the carboxymethyl group [19]. The factors that affect DS and are investigated here are starch type and amount of alkaline used; other factors can be substituent concentration, reaction temperature, and time, type of solvent and water content (see table 2).

The results of DS measurements (table 2) showed a medium degree of substitution (DS 0.50-0.82) on both sago and cassava starches, and the amount of NaOH concentration added does not affect the effectiveness of the alkalization reaction. This fact is related to the statement of Ref. [3], that the increasing of NaOH concentration in the reaction will increase the DS value. The higher NaOH concentration used will make the etherification reaction better because of the increased reactivity of the alkali starch to SMCA used in the reaction. The DS value for samples prepared with the homogenizer are higher than when mixed with a magnetic stirrer. During homogenization smaller droplets are made that are more reactive, leading to more reactive alkali starch groups so that etherification reaction can run more optimally.

*3.2.2. Paste Clarity.* The clarity level of starch paste is positively correlated with the swelling of starch granules (table 3); high swellability increasing the clarity of pastes [20]. Table 3 shows that clarity of Na-carboxymethyl starch pastes is higher than for native starch. The starch produced using a magnetic stirrer tends to have higher clarity than those produced using a homogenizer; the differences between cassava and sago are very small. Homogenization will cause the expansion of the amorphous regions resulting from the alkalization step which is positively correlated with water and oil absorption capacity.

•	Native –	Magnetic Stirring		Homogenizing		
Parameter	Starch	Moles of NaOH per mole AGU				
		1.8	1.9	1.8	1.9	
Cassava Starch						
1% Paste Clarity (%T)	$81.03\pm0.21^{a}$	$98.05\pm0.48^{\rm c}$	$97.58\pm0.49^{\rm c}$	$90.15\pm0.27^{\text{b}}$	$89.80\pm0.36^{\text{b}}$	
Water absorption capacity (%)	$172.00\pm0.01^{a}$	$986.44\pm0.54^{b}$	$987.00\pm0.56^{\text{b}}$	$989.56\pm0.81^{\text{c}}$	$990.78 \pm 1.36^{\rm c}$	
Oil absorption capacity (%)	$131.00\pm0.33^a$	$200.89\pm0.54^{b}$	$201.56\pm1.56^{b}$	$204.67\pm0.94^{c}$	$205.89\pm0.98^{\circ}$	
Solubility at 70 °C	$14.00\pm0.01^{a}$	$44.00\pm2.53^{\text{b}}$	$46.67\pm2.07^{b}$	$68.00 \pm 1.89^{\rm c}$	$70.00\pm0.94^{\text{c}}$	
Swelling power at 70 °C	$9.07\pm0.01^{\rm a}$	$13.57\pm0.64^{b}$	$14.01\pm0.40^{b}$	$15.32\pm0.18^{\rm c}$	$15.97\pm0.72^{\circ}$	
Sago Starch						
1% Paste Clarity (%T)	$76.47\pm0.31^{\rm a}$	$96.50\pm0.35^{\rm c}$	$96.28\pm0.68^{c}$	$89.85\pm0.63^{b}$	$89.82\pm0.57^{b}$	
Water absorption capacity (%)	$110.67\pm0.94^{\mathrm{a}}$	$836.11 \pm 1.86^{\text{b}}$	$838.67\pm3.10^{b}$	$982.44\pm0.81^{\text{c}}$	$982.89 \pm 1.96^{c}$	
Oil absorption capacity (%)	$120.67\pm0.67^{\mathrm{a}}$	$182.11\pm0.89^{b}$	$184.11\pm0.50^{\rm c}$	$201.00\pm0.81^{\text{d}}$	$202.00 \pm 1.84^{d}$	
Solubility at 70 °C	$20.00\pm0.01^{\rm a}$	$60.00\pm2.53^{b}$	$62.67\pm2.07^{b}$	$85.33\pm2.07^{\rm c}$	$87.33 \pm 1.63^{\rm c}$	
Swelling power at 70 °C	$9.30\pm0.01^{\rm a}$	$12.73\pm0.33^{\text{b}}$	$12.80\pm0.30^{b}$	$14.11\pm0.29^{\rm c}$	$14.32\pm0.73^{\circ}$	

Table 3. Physico-chemical characteristics of Na-carboxymethyl starch

\*Means within a row related to particular parameter with the same superscript letter are not significantly different as  $\alpha=0.05$  confidence level.

IOP Conf. Series: Earth and Environmental Science 147 (2018) 012016 doi:10.1088/1755-1315/147/1/012016

**IOP** Publishing

3.2.3. Water and Oil Absorption Capacity. Table 3 shows that water absorption of starch increased after modification for both cassava and sago starch; which is in line with [23]. As mentioned, this increase occurs due to the loss of the crystalline structure [24], which weakens the structure of starch granules so water can easily enter. The ability of starch to absorb oils shows that starch also has a lipophilic portion. Oil absorption capacity is used to measure the product hydrophobicity; the increase in oil absorption is caused by the introduction of the Na-carboxymethyl group (CH<sub>2</sub>COONa). The Na-carboxymethyl starch will absorb the oil in the form of a fatty acid (R-COOH). The tendency to bind between fatty acids and Na-carboxymethyl starch is related to the same molecular polarity. Natural starch (R-OH) will have more difficulty to bind to fatty acid (R-COOH) due to differences in polarity.

*3.2.4. Swelling and solubility.* Sodium carboxymethyl starch is cold water soluble starch, has high dispersed distribution, and excellent water absorption capacities compared to native starch. Carboxymethylation can improve the swelling and solubility of native cassava and sago starches (table 3). Sago starch revealed slightly higher solubility compared to cassava starch, since sago and cassava starches contained different amounts of amylose 25.12% and 19.15%, respectively and as a result different crystallinity. During the modification process, the molecular weight decreases and the degree of polymerization decreases [25], leading to an increase in the hydrophilic nature of starch [26]. The crystalline structure weakens and makes the starch more easily hydrated by water [16].

#### 4. Conclusions

The production of Na-carboxymethyl starch can be carried out by carboxymethylation process using NaOH as an alkalizing agent and SMCA as etherification agent. The alkalization step becomes the initial stage that will affect to the etherification stage. The stirring type of the alkalization stage affects the efficiency of the reaction. The type of starch affects the characteristics of Na-carboxymethyl starch which is related to amylose and amylopectin compositions, but not too much. The highest DS values were found for sago starch treated with NaOH using a homogenizer that also has positive effect on paste clarity, solubility, swelling power, water absorption, oil absorption.

#### Acknowledgement

This publication is part of the research funded by The Indonesian Ministry of Research, Technology, and Higher Education through National Strategic Research Program No. 079/SP2H/LT/DRPM/II/2016 to Titi Candra Sunarti, Bogor Agricultural University.

#### References

- [1] Liu Q 2005 Food Carbohydrates: Chemistry, Physical Properties and Applications (Boca Raton: Taylor & Francis)
- [2] Wurzburg O B 1986 *Modified Starches: Properties and Uses* (Florida: CRC Pr.)
- [3] Sangseethong K, Ketship S and Sriroth K 2005 Starch 57 84
- [4] Shah U and Augsburger L 2002 *Pharm Develop Technol* **7** 345–359
- [5] Ragheb A A, El-Sayiad H S and Hebeish A 1997 Starch 49 238–245
- [6] Tatongjai J and Lumdubwong N 2010 Carbohyd Polym 81 377–384
- [7] Lawal O S, Lechner M D and Kulicke W M 2008 Int J Biol Macromol 42 429-435
- [8] Hasannudin M 2015 Factors affecting reaction rate.(in Indonesian). [accessed at 31 Januari 2017]. http://kimiadasar.com/faktor-faktor-yang-mempengaruhi-laju-reaksi/
- [9] Yaacob B, Amin M, Hashim K and Bakar B Iranian Polym. 20(3): 195–204
- [10] [ISO] International Organization for Standardization 1998 (Geneva: Intenational Organization for Standardization)
- [11] Li Y, Liu C, Tan Y, Xun K, Lu C and Wang P 2014 Carbohydr. Polym. 110 87
- [12] Hu X 2013 Cereal Chem. 90 24
- [13] Ester R F, John K, Xin Q 2004 J Cereal Sci. 39 151–165
- [14] Flach M 1983 Thes Sago Palm. Food and Agriculture Organization of United Nation (Rome: FAO)

AESAP 2017

IOP Conf. Series: Earth and Environmental Science 147 (2018) 012016 doi:10.1088/1755-1315/147/1/012016 S/Q

**IOP** Publishing

- [15] Rickard J E, Blanshard J M V and Asaoka M 1992 J Sci Food Agric. 59 53-58
- [16] Chen J and Jane J 1994 Cereal Chem. 71 623
- Kooijmana L M, Ganzeveld K J, Manurung R M and Heeres H J 2003 Starch 55 495 [17]
- [18] Earle R L 1983 Unit operations in food processing 2<sup>nd</sup> Edition (Oxford: Pergamon Press)
- Zhou X and Yang Q G 2007 J Mater Process Technol 183 407-411 [19]
- Suriani A R 2008 Study of Effects of Heating and Repeated Cooling on Physical and Functional [20] Characteristics of Garut Modified Starch (Marantha arundinacea) (In Indonesian) (Bogor: Bogor Agricultural University)
- Thitipraphunkul K, Uttapap D, Piyachomkwan K and Takeda Y 2003 Carbohyd Polym. 53 317-[21] 324
- Zayas J F 1997 Functional of Proteins in Food (Jerman: Springer-Verlag) [22]
- [23] Collado L S and Corke H 1999 Food Chem. 65 339-346
- Spychaj T, Zdanowicz M, Kujawa J and Schmidt B 2013 Starch 65 22 [24]
- Jiao L V, Tan S, Peng L, Chen H and Liu X 2013 Mater Appl. 2(2): 1-11 [25]
- [26] Cardoso M B, Putaux J L, Samios D and da Silveira N P 2007 Carbohydr Polym 70 160–165