FINAL ORAL EXAMINATION
FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

OF

INNEKE ROOS MARY VICTOR
DEPARTMENT OF BIORESOURCE ENGINEERING
PROCESSING OF ARENGA PINNATA (PALM) SUGAR

Friday, March 27, 2015
1:15 p.m.

RAYMOND BUILDING, Room R3-045
McGill University, Macdonald Campus

COMMITTEE:
Dr. A. Biswas (Pro-Dean) (Natural Resource Sciences)
Dr. Z. Qi (Chair) (Bioresource Engineering)
Dr. V. Orsat (Supervisor) (Bioresource Engineering)
Dr. M-J. Dumont (Internal Examiner) (Bioresource Engineering)
Dr. G.S.V. Raghavan (Internal Member) (Bioresource Engineering)
Dr. H. Monardes (External Member) (Animal Science)

Dr. Martin Kreiswirth, Dean of Graduate and Postdoctoral Studies
Members of the Faculty and Graduate Students
are invited to attend
ABSTRACT

*Arenga pinnata* sugar has been consumed by the local people of Indonesia for decades. In Tomohon, Indonesia, the sugar has been processed following the indigenous knowledge which consists of minimal process parameters. The sugar is considered to be potentially better for your health for which sufficient information is not yet available. This study has focused on developing knowledge on the process parameters involved in producing *Arenga pinnata* sugar from the sap, which is needed to improve existing process techniques to enhance the quality of produced sugar, and on the characterization of the sugar which will help the farmers to gain a better market positioning for their sugar.

The first study investigated the changes in *Arenga pinnata* sap, as a raw material, following the harvesting identified by pH, invert sugar and colour changes. As the time increased, the pH of the sap decreased and the invert sugar increased. Colour measurements following CIELAB (*L*a*b* colour space) indicated that the change in pH of the sap is more associated with *L* and *b* values. The results confirmed the hypothesis that these parameters can be used as indicators of deterioration of the sap.

Processing the sap into sugar, by the removal of water through boiling, was carried out in the second study. Physical and chemical transformations involved during the heating process were observed by their changes in temperature, pH and Total Soluble Solids (TSS). The pH increased in the beginning of the heating process until it reached a peak at the boiling point, followed by a continuous decrease to the end of the heating process. The final temperature of the concentrated sap was about 127°C corresponding to a TSS of more than 93 (% w/w) and pH values close to the initial pH of the fresh sap.

The colour changed significantly during the process steps involved in sugar processing, i.e., from the heating of the sap until it became a thick syrup, to the production of solid sugar, and the stirring process of the thickened syrup to form granulated sugar. CIELAB (*L*a*b* colour space) and several colour determinations, namely total colour difference (ΔE*), hue angle (h), chroma (C*) and a*/b* ratio were determined in the study. As a function of time, the sap became darker (*L* decreased), more red (*a* increased), and more yellow (*b* increased) during the heating process. During the stirring process the sugar became lighter (*L* increased), more red (*a* increased), and more yellow (*b* increased). The colour of the solid sugar was significantly different than the colour of the granulated sugar (by ΔE*),
nonetheless both sugars can be categorized as having red-orange to yellow-orange colour (by $h$) with more yellow (by $a^*/b^*$ ratio) and colourful appearance (by $C^*$).

The final study examined the physico-chemical attributes of granulated *Arenga pinnata* sugar. The sugar showed unique characteristics with an average pH of 6.285, 93.4% total sugar content, 2.98% invert sugar, yellow in colour (by hue angle $h$ and $a^*/b^*$ ratio values), and nutritional properties with a high total phenolic compounds content (2432 µg/g of GAE), and antioxidant potential identified by free radical scavenging activity ($IC_{50}$) of 0.6 mg/ml. The Fourier transform infrared spectroscopy (FTIR) spectra of the sugar confirmed that sucrose was the main sugar in *Arenga pinnata* sugar, and the tendency of the granules to clump together was identified using scanning electron microscopy (SEM) images.

This study contributes to improving the existing practices applied by indigenous people through better understanding of the important quality parameters involved during processing of the fresh sap into sugar. The findings from this work not only will serve as a base for future studies on *Arenga pinnata* sugar production, but also help the farmers to develop a better market for their sugar.

### CURRICULUM VITAE

#### UNIVERSITY EDUCATION

2010 - Now  
Ph.D. Bioresource Engineering, McGill University, Canada

2001 - 2002  
MEngSc. Process Engineering, The University of New South Wales, Australia

1990 - 1996  
B.Tech. Industrial Engineering, Institut Teknologi Minaesa, Indonesia

#### EMPLOYMENT

2005 - Now  
Civil servant at Kopertis Wilayah IX Sulawesi, Indonesia

2002 - 2010  
Lecturer at Institut Teknologi Minaesa and at De La Salle Catholic University, Manado, Indonesia

1997 - 2000  
Lecturer at Institut Teknologi Minaesa, Manado, Indonesia

#### AWARDS

2014  
1st place in the Food Safety Without Borders Graduate Paper Competition, IUFoST World Congress of Food Science and Technology, Montreal, Canada

2010 - 2013  
The Indonesian Directorate General of Higher Education (DIKTI) scholarships for Indonesian lecturer

2004  
The Netherlands government for quality care system training

2001 - 2002  
Australian Development Scholarships (ADS)
PUBLICATIONS
2. Inneke Victor and Valérie Orsat. *Arenga pinnata* sap and its potential as a sweetener using controlled processing parameters – a review paper (prepared and to be submitted).
3. Inneke Victor and Valérie Orsat. Study of pH, invert sugar and colour changes of *Arenga pinnata* sap (prepared and to be submitted).
4. Inneke Victor and Valérie Orsat. Changes in temperature, total soluble solids (TSS), and pH during the heating process of *Arenga pinnata* sap (prepared and to be submitted).
5. Inneke Victor and Valérie Orsat. Colour changes during the processing of *Arenga pinnata* sap into sugar (prepared and to be submitted).

CONFERENCE PRESENTATIONS