END OF PROJECT REPORT

A. Project number: 03-62-65-1067EA001

Project title: Development of Enzymatically-debranched Starch Products from Sago and Tapioca Starch for Use as Fat Replacers in Foods

Project leader: Prof Madya Dr Norziah Mohd Hani

Tel: 04-6532222 **Fax: 04-6573678**

B. Describe your project and highlight major project development

An enzymatic hydrolysis process was developed to produce starch fractions of certain composition consisting of amylose and amylopectin polymers. The method involves the use of a debranching enzyme whereby starch fractions consisting of linear chain lengths of different degree of polymerisation were produced. These starch fractions were characterised in terms of amylose contents, thermal and rheological characteristics. The hydrolysis process was optimised (24 hrs hydrolysis time, 10% pullulanase enzyme, pH 5.0 and 60°C) to obtain linear starch fractions consisting of > 50% amylose content which are suitable as functional replacement of fat. These starch products were also found to be suitable for developing edible films and coatings which was not in the objective of project. Thus studies were also carried out in the development of edible films and the results showed it has potential for application in food industry.

Applications of these enzymatically debranched starch products were conducted in 2 aspects:

(i) As carbohydrate-based fat replacers: Replacing fat for these starch fractions in 2 types of food formulation containing low (white sauces) and high fat (mayonnaise) content gave reduction in calories of about 45% and 84% respectively. But these results were achieved using sago starch but not with tapioca starch.

(ii) As edible films and coatings for food products: These starch products were formulated in combination with hydrocolloids and films were made by casting method. These coating were found to be able to extend the shelf-life of a traditional snack food product.

C. Objectives achievement

- **Original programme/project objectives after approval**

1. To develop an enzymatic process for producing novel starch compositions from sago and tapioca starches suitable for functional replacement for fat in foods.
2. To produce enzymatically debranched starch products comprise of a mixture of short chain amylose and partially debranched amylopectin in powdered or as dispersion in the liquid.
3. To produce granular starch suitable as fat replacements in foods

- **Objectives Achieved** (Please state the extent to which the project objectives were achieved)

Objectives to develop an enzymatic starch modification process to produce debranched starch products and granular starch from sago starch were fully achieved. The work also includes physico-chemical and rheological characterizations of these starch compositions. Application and evaluation of the starch fractions containing >50% linear chain amylose content in 2 selected food systems were successfully performed. From sensory evaluations and textural studies it was concluded that these starch fractions are found to be suitable functional replacement for fat in foods.

- **Objectives not achieved** (Please identify the objectives that were not achieved and give reasons)

Objectives not achieved are for work using tapioca starch. Tapioca starch seemed to be less susceptible to enzymatic attack, thus optimisation of the debranching hydrolysis process was unattained. The debranching process was slow and thus starch fractions containing >50% linear chain amylose was not obtained. A possible reason to this slow hydrolysis process is that the granular structure of tapioca starch is probably more compact and that branched amylopectin chains may be located in the interior part of starch granule thus making it inaccesible to the debranching enzyme as was observed through SEM studies.

- **Achievement of overall objectives**

[√] Yes

[ ] No

D. Technology Transfer/Commercialisation Approach

- **Comercialisation potential**

[ ] Yes

[√] No

Please describe the approach planned to transfer/commercialize the results of the project:

E. Benefits of the Project (Please identify the actual benefits arising from the project as defined in Section III of the Application Form. For examples of outputs, organisational outcomes and sectoral/national impacts, please refer to Section III of the Guidelines for the Application of R&D Funding under IRPA)

- **Outputs of the project and potential beneficiaries** (Please describe as specifically as possible the outputs achieved and provide an assessment of their significance to users)

Outputs:

- Enzymatic debranching process for producing novel starch compositions having fat mimic characteristics
- Carbohydrate fat based replacers as functional ingredients in foods

Potential beneficiaries:

- Food ingredient manufacturers and suppliers
- Sago and tapioca starch industry

- **Organisational Outcomes** (Please describe as specifically as possible the organisational benefits arising from the project and provide an assessment of their significance)

- Training of research staff, postgraduate students and supporting staff in research techniques and the use of specialised equipment.
- Increase in the numbers of postgraduate students thus contributing toward human resource development.
- Linkages with the industry
- New information network

- **National Impacts** (If known at this point in time, please describe as specifically as possible the potential sectoral/national benefits arising from the project and provide an assessment of their significance)

- Human resource development
- Domestic industry linkages (food ingredient suppliers)
- Linkages with domestic research institutions (e.g. Sarawak sago industry)
- Increase and better utilization of sago and tapioca starch

F. Assessment of project structure

- **Project Team** (Please provide an assessment of how the project team performed and highlight any significant departures from plan in either structure or actual man-days utilised).

The project team performed the research as planned except for one of the team researcher has retired during the last year of project. This however did not effect the project schedule.

- **Collaborations** (Please describe the nature of collaborations with other research organisations and/or industry)

Collaborations with researchers in another local university (UKM) and research organisation, MARDI in the form of setting up a starch research team to work on various aspects of research in starch (e.g. from biosynthesis to downstream). Another effect to bring together researchers in the starch area is organising a conference on starch in collaboration with MARDI in June 2005.

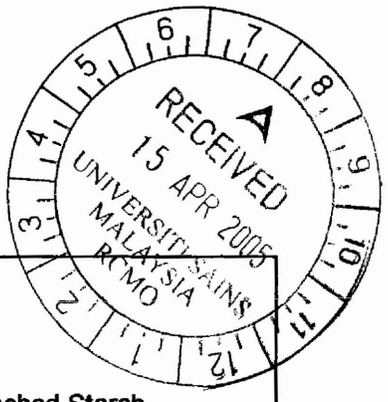
G. Assessment of Research Approach (Please highlight the main steps actually performed and indicate any major departure from the planned approach or any major difficulty encountered)

1. **Starch debranching process. Enzymatic debranching process was conducted in various sizes of shake flasks in a dry orbital shaker :**
2. **Process optimization:** Different concentrations of pullulanase enzyme and duration of hydrolysis were used in order to obtain starch fractions having fat functionality. The optimum temperature, substrate concentration, pH, the presence or absence of inhibitors and other factors affecting enzyme activity was investigated.
3. **Physico-chemical characterization of starch compositions**: The debranched starch fractions produced containing different compositions of linear fractions (amylose) and amylopectin was evaluated for its molecular weight distributions using gel permeation chromatography (GPC). However we encountered many problems in obtaining molecular weight distributions by this GPC method using the light scattering detector. These problems are finding suitable solvents (such as DMSO) for dissolution of the starch fractions without gelatinizing the samples and obtaining suitable columns for performing aqueous GPC system. Thus a detailed characterization of molecular weight distribution of these starch fractions was not achieved which was crucial as it has significant impact on the assessment of its fat functionility. This could be achieved with other better methods such as gel permeation chromatography coupled with multiangle laser light scattering or high-performance anion-exchange chromatography using a pulsed amperometric detector.
4. **Application:** These starch fractions (as functional ingredients) was succesfully applied in the formulation of 2 types of food to assess their performance as fat replacers.

H. Assessment of the Project Schedule (Please make any relevant comment regarding the actual duration of the project and highlight any significant variation from plan)

The project was extended for another 6 months since the principal investigator was on a sabbatical leave for 6 months in UK. Thus the extension was necessary in order to allow time for completion of project.

M. Remarks by IRPA Institution Coordinator
N. Remarks by Program Leader
O. Remarks by Lead Institution Coordinator
P. Remarks by Monitoring Unit
Date:



BENEFITS REPORT

I. DESCRIPTION OF THE PROJECT

A. Project identification

1.	**Project number:**	03-62-65-1067EA001
2.	**Project title:**	Development of Enzymatically-debranched Starch Products from Sago and Tapioca Starch for Use as Fat Replacers in Foods
3.	**Project leader:**	Prof Madya Dr Norziah Mohd Hani

B. Type of research

Indicate the type of research of the project (Please see definitions in the Guidelines for completing the Application Form)

- ☐ Scientific research (fundamental research)
- ☐ Technology development (applied research)
- ☑ Product/process development (design and engineering)
- ☐ Social/policy research

C. Objectives of the project

1. Socio-economic objectives

Which socio-economic objectives are addressed by the project? (Please identify the Sector, SEO Category and SEO Group under which the project falls. Refer to the Malaysian R&D Classification System brochure for the SEO Group code)

Sector:	Manufacturing
SEO Category:	Manufacturing (S20600)
SEO Group and Code:	Processed food products & beverages (S20601)

2. Fields of research

Which are the two main FOR Categories, FOR Groups, and FOR Areas of your project? (Please refer to the Malaysian R&D Classification System brochure for the FOR Group Code)

a. Primary field of research

FOR Category:	Applied Science and Technology
FOR Group and Code:	Resource-based industry (F10605)
FOR Area:	Food Industry

b. Secondary field of research

FOR Category:	Agricultural Sciences (F10900)

FOR Group and Code:	Food and Nutrition development (F10908)
FOR Area:	Improvement of finished product

D. Project duration

What was the duration of the project?

36 Months

E. Project manpower

How many man-months did the project involve?

40.7 Man-months

F. Project costs

What were the total project expenses of the project?

RM 230,000.00

G. Project funding

Which were the funding sources for the project?

Funding sources	Total Allocation (RM)
IRPA	230,000.00

II. DIRECT OUTPUTS OF THE PROJECT

A. Technical contribution of the project

1. What was the achieved direct output of the project:

For scientific (fundamental) research projects?

- ☐ Algorithm
- ☐ Structure
- ☐ Data
- ☐ Other, please specify: _____

For technology development (applied research) projects:

- ☐ Method/technique
- ☐ Demonstrator/prototype
- ☐ Other, please specify: _____

For product/process development (design and engineering) projects:

- ☑ Product/component
- ☑ Process
- ☐ Software
- ☐ Other, please specify:

2. How would you characterise the quality of this output?

- ☐ Significant breakthrough
- ☑ Major improvement
- ☐ Minor improvement

B. Contribution of the project to knowledge

1. How has the output of the project been documented?

- ☑ Detailed project report
- ☐ Product/process specification documents
- ☐ Other, please specify: _____

2. Did the project create an intellectual property stock?

- ☐ Patent obtained
- ☐ Patent pending
- ☐ Patent application will be filed
- ☐ Copyright

3. What publications are available?

- ☐ Articles (s) in scientific publications — How many: _____
- ☑ Paper(s) delivered at conferences/seminars — How many: 3
- ☐ Book
- ☐ Other, please specify: _____

4. How significant are citations of the results?

- ☐ Citations in national publications — How many: _____
- ☐ Citations in international publications — How many: _____
- ☑ Not yet
- ☐ Not known

III. ORGANISATIONAL OUTCOMES OF THE PROJECT

A. Contribution of the project to expertise development

1. How did the project contribute to expertise?

[√] PhD degrees — How many: One
Name: Budi Saneto
Nationality: Indonesian
Area expertise: Starch modification technology

[√] MSc degrees — How many: One
Name: Khalifatul Maria Mohktar
Nationality: Malaysian
Area expertise: Starch & enzyme technology

[√] Research staff with new specialty — How many: One
Name: Hong Lee Fen
Nationality: Malaysian
Area expertise: Gel permeation chromatography

[ ] Other, please specify: Final year projects student

2. How significant is this expertise?

[ ] One of the key areas of priority for Malaysia

[√] An important area, but not a priority one

B. Economic contribution of the project?

1. How has the economic contribution of the project materialised?

[ ] Sales of manufactured product/equipment

[ ] Royalties from licensing

[ ] Cost savings

[ ] Time savings

[ ] Other, please specify: Not yet

2. How important is this economic contribution?

[ ] High economic contribution — Value: RM _____

[ ] Medium economic contribution — Value: RM _____

[ ] Low economic contribution — Value: RM _____

3. When has this economic contribution materialised?

- [ ] Already materialised
- [ ] Within months of project completion
- [ ] Within three years of project completion
- [√] Expected in three years or more
- [ ] Unknown

C Infrastructural contribution of the project

1. What infrastructural contribution has the project had?

- [√] New equipment — Value: RM 18,740.00 (dry orbital incubator shaker)
- [ ] New/improved facility — Investment: RM _____
- [√] New networking
- [ ] Other, please specify: _____

2 How significant is this infrastructural contribution for the organisation?

- [ ] Not significant/does not leverage other projects
- [√] Moderately significant
- [ ] Very significant/significantly leverages other projects

D. Contribution of the project to the organisation's reputation

1. How has the project contributed to increasing the reputation of the organisation

- [ ] Recognition as a Center of Excellence
- [ ] National award
- [ ] International award
- [√] Demand for advisory services
- [ ] Invitations to give speeches on conferences
- [ ] Visits from other organisations
- [ ] Other, please specify: _____

2 How important is the project's contribution to the organisation's reputation?

- [ ] Not significant
- [ ] Moderately significant
- [√] Very significant

IV. NATIONAL IMPACTS OF THE PROJECT

A. Contribution of the project to organisational linkages

1. Which kinds of linkages did the project create?

- [√] Domestic industry linkages
- [ ] International industry linkages
- [√] Linkages with domestic research institutions, universities
- [√] Linkages with international research institutions, universities

2 What is the nature of the linkages?

- [ ] Staff exchanges
- [ ] Inter-organisational project team
- [ ] Research contract with a commercial client
- [√] Informal consultation
- [ ] Other, please specify: _____

B. Social-economic contribution of the project

1. Who are the direct customer/beneficiaries of the project output?

Customers/beneficiaries:	Number:
Sago and tapioca starch industry	One

2. How has/will the socio-economic contribution of the project materialised?

- [√] Improvements in health
- [ ] Improvements in safety
- [ ] Improvements in the environment
- [ ] Improvements in energy consumption/supply

☐ Improvements in international relations

☐ Other, please specify: _____

3. How important is this socio-economic contribution?

☐ High social contribution

☑ Medium social contribution

☐ Low social contribution

4 When has/will this social contribution materialised?

☐ Already materialised

☐ Within three years of project completion

☑ Expected in three years or more

☐ Unknown

V. REMARKS

A. Remarks by IRPA Institution Coordinator
B. Remarks by Program Leader
C. Remarks by Lead Institution Coordinator
D. Remarks by Monitoring Unit
Date: