



**UNIVERSITI PUTRA MALAYSIA**

***EFFECTS OF PRE- GELATINIZED STARCH INCLUSION IN PELLET ON  
GROWTH AND PHYSIOLOGICAL PARAMETERS OF TWO  
COMMERCIAL AQUACULTURE SPECIES***

**NAGAKANMANI A/P MUNIANDY**

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By

**NAGAKANMANI A/P MUNIANDY**

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in  
Fulfilment of the Requirement for the Degree of Master of Science**

**February 2018**

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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By

**NAGAKANMANI D/O MUNIANDY**

**February 2018**

**Chairman : S. M. Nurul Amin, PhD**  
**Faculty : Agriculture**

A 9-week study was conducted to compare the use of dietary corn starch (CS) or tapioca starch (TS), with or without being pre-gelatinized (PG), on the growth, feeding efficiencies, plasma biochemistry, whole-body proximate composition, muscle cholesterol, muscle fatty acid composition, intestinal short chain fatty acids (SCFA), and liver glycogen and histopathology of red hybrid tilapia (*Oreochromis* sp.). Triplicate groups of 20 fish (initial mean weight =  $0.739 \pm 0.01$  g) were fed their respective diets to satiation. Various pellet characteristics were also measured that included bulk density (BD), expansion ratio (ER), pellet durability index (PDI), water solubility index (WSI), water absorption index (WAI), and water stability (WS) while the surface microstructure was examined.

Results showed that tilapia fed the TS diet had significantly lower growth ( $p < 0.05$ ) than all other treatments, but was significantly improved when pre-gelatinized. In the PG dietary treatments, intestinal SCFA significantly decreased while plasma glucose, cholesterol and triglycerides as well as liver glycogen were significantly higher compared to the native starch diets. Whole-body proximate composition and muscle cholesterol were unaffected by dietary treatments, although fish in the CS treatment had significantly higher amounts of long chain polyunsaturated fatty acids compared to the other treatments. The PG diets had significantly higher PDI, WS, WSI and BD compared to native starch diets. The surface morphology generally showed a smoother surface for the PG diets.

While dietary TS was inferior compared to CS for tilapia, the PG-TS diet significantly improved their growth and feeding efficiencies and moreover the PG diets led better pellet characteristics that are likely to have important implications to the production of aquafeeds. Therefore, for the second experiment the tapioca starch was chosen and

tested with African catfish. Tilapia and African catfish are the common commercial species that been farmed world wide.

A 7-week study was conducted to compare the use of dietary tapioca starch and pre gelatinized tapioca starch with or without IMO on the growth, feeding efficiencies and muscle proximate composition of African catfish, *Clarias Gariepinus*. Triplicate groups of 15 fish (initial mean weight =  $6.2 \pm 0.3$  g) were fed their respective diets to satiation. Various pellet characteristics were also measured that included bulk density (BD), pellet durability index, water solubility index (WSI), water absorption index (WAI), and water stability (WS).

Results showed that there are no significance differences between treatments in growth of catfish ( $p > 0.05$ ). The native starches with and without iso- maltose shows significantly lower water stability while the pre- gelatinized starch with and without iso- maltose showing high water stability. The water absorption index also shows significantly different between the native starches and pre- gelatinized starch. In overall, pre- gelatinized starches reduced the feed intake without compromising growth. As well, there were some negative effects to the nutritive value of the fish but it was mitigated by the addition of the prebiotic. Therefore, the pre- gelatinized tapioca starch can reduce the cost of production and as well help to maintain the water quality.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Sarjana Sains

**KESAN PENGGUNAAN KANJI PRA- GEL DALAM PELLET TERHADAP TUMBESARAN DAN CIRI- CIRI FIZIKAL DUA SPESIES KOMERSIAL AKUAKULTUR**

Oleh

**NAGAKANMANI A/P MUNIANDY**

**Februari 2018**

**Pengerusi : S. M. Nurul Amin, PhD**  
**Fakulti : Pertanian**

Satu kajian selama 9 minggu dijalankan untuk membandingkan penggunaan kanji jagung (CS) dan kanji ubi kayu yang sudah digel atau yang belum digel (PG), terhadap pertumbuhan, kecekapan pemakanan, biokimia plasma, komposisi proximat seluruh badan, kolesterol otot, komposisi asid lemak, asid lemak rantaian pendek usus (SCFA) dan glikogen hati serta histopatologi tilapia hybrid merah (*Oreochromis sp.*).

Sebuah akuarium diisikan dengan 20 ekor ikan (berat minimum awal =  $0.739 \pm 0.01$  g) dan diberikan makanan rawatan yang disediakan sehingga kenyang serta setiap rawatan digandakan kepada tiga kali ganda. Pelbagai ciri-ciri pellet diperiksa iaitu ketumpatan pukal (BD), kadar pengembangan (ER), daya ketahanan pellet (PDI), indeks kelarutan air (WSI), indeks penyerapan air (WAI), dan kestabilan air (WS) serta mikrostruktur permukaan.

Hasil kajian menunjukkan tilapia yang diberi makan makanan TS mempunyai pertumbuhan yang kurang dengan ketara ( $p < 0.05$ ) daripada makanan rawatan yang lain, tetapi pertumbuhannya bertambah baik apabila digel. Dalam rawatan pemakanan PG, SCFA usus menurun secara ketara sementara glukosa, kolesterol dan trigliserida plasma serta glikogen hati lebih tinggi berbanding dengan diet kanji asli atau yang tidak digel. Komposisi proximat dan kolesterol otot tidak ada perbezaan antara rawatan pemakanan, walaupun ikan dalam rawatan CS mempunyai rantaian panjang asid lemak tak tepu yang jauh lebih tinggi dibandingkan dengan rawatan lain. Diet PG mempunyai PDI, WS, WSI dan BD yang tinggi berbanding dengan diet kanji yang asli. Walaupun diet TS menunjukkan pertumbuhan yang kurang baik berbanding dengan diet CS, tetapi diet PGTS menunjukkan pertumbuhan yang baik dan kecekapan pemakanan serta ciri-ciri pellet yang lebih baik dimana ia boleh mempunyai implikasi yang penting terhadap pengeluaran makanan ikan. Oleh sebab itu, untuk eksperimen yang kedua, kanji ubi

kayu dipilih untuk diuji dengan ikan keli. Ikan tilapia dan keli dipilih kerana kedua spesies ini merupakan spesies komersial yang diternak secara luas di seluruh dunia.

Satu lagi kajian dijalankan selama 7 minggu untuk membandingkan penggunaan kanji ubi kayu asli dan yang digel dengan atau tanpa IMO pada pertumbuhan, kecekapan pemakanan dan komposisi proximat otot ikan keli Afrika, *Clarias gariepinus*. Sebanyak 15 ekor ikan dimasukkan ke dalam satu akuarium (berat minimum awal =  $6.2 \pm 0.3$  g) dan diberi makanan rawatan sehingga kenyang serta setiap rawatan digandakan kepada tiga kali ganda. Pelbagai ciri- ciri pellet juga diuji termasuk ketumpatan pukal (BD), kadar pengembangan (ER), daya ketahanan pellet (PDI), indeks kelarutan air (WSI), indeks penyerapan air (WAI), dan kestabilan air (WS).

Hasil kajian menunjukkan bahawa tiada perbezaan yang dikenal pasti dari segi pertumbuhan antara rawatan. Kanji asli dengan dan tanpa iso- maltose menunjukkan kestabilan air yang rendah manakala kanji yang digel dengan dan tanpa iso maltose menunjukkan kestabilan air yang tinggi. Indeks penyerapan air (WAI) juga menunjukkan perbezaan yang ketara antara rawatan. Secara keseluruhan, kanji yang digel mengurangkan pengambilan makanan tetapi tidak menjejaskan pertumbuhan ikan. Selain itu, terdapat beberapa kesan negatif terhadap nilai pemakanan ikan tetapi ia dapat diatasi dengan penambahan prebiotic. Oleh itu, kanji ubi kayu yang digel boleh mengurangkan kos pengeluaran dan membantu untuk mengekalkan kualiti air.

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This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirements for the degree of Master of Science. The members of Supervisory Committee were as follows:

**S. M. Nurul Amin, PhD**  
Associate Professor  
Faculty of Agriculture  
Universiti Putra Malaysia  
(Chairman)

**Nicholas Romano, PhD**  
Senior Lecturer  
Faculty of Agriculture  
Universiti Putra Malaysia  
(Member)

---

**ROBIAH BINTI YUNUS, PhD**  
Professor and Dean  
School of Graduate Studies  
Universiti Putra Malaysia

Date: 16 August 2018

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Name and Matric No.: Nagakanmani A/P Muniandy, GS44426

## TABLE OF CONTENTS

	<b>Page</b>
<b>ABSTRACT</b>	i
<b>ABSTRAK</b>	iii
<b>ACKNOWLEDGEMENTS</b>	v
<b>APPROVAL</b>	vi
<b>DECLARATION</b>	viii
<b>LIST OF TABLES</b>	xv
<b>LIST OF FIGURES</b>	xvi
<b>LIST OF ABBREVIATIONS</b>	xvii
<b>CHAPTER</b>	
<b>1</b>	
<b>INTRODUCTION</b>	1
1.1 Background of study	1
1.2 Significant of study	1
1.3 Problem statement and hypothesis	2
1.4 Research objectives	2
<b>2</b>	
<b>LITERATURE REVIEW</b>	3
2.1 Aquaculture	3
2.2 Carbohydrates	3
2.2.1 Carbohydrate usage in aquaculture	5
2.2.2 Types of carbohydrates	6
2.2.2.1 Saccharides	6
2.2.2.2 Polysaccharides	7
2.2.3 Carbohydrates potential	9
2.3 Starch	10
2.3.1 Starches usage in aquaculture	11
2.3.2 Types of starches	13
2.3.2.1 Native starches	13
2.3.2.2 Pre- gelatinized starch	14
2.4 Fish	15
2.4.1 Red hybrid tilapia, <i>Oreochromis spp</i>	16
2.4.2 African catfish, <i>Clarias gariepinus</i>	16

<b>3</b>	<b>GENERAL METHODOLOGY</b>	<b>18</b>
3.1	Introduction	18
3.2	Methods	18
3.2.1	Location of study	18
3.2.2	Water quality parameters	18
3.2.3	Data collection	19
3.2.4	Chemical analysis	19
3.2.4.1	Determination of moisture	19
3.2.4.2	Determination of crude protein	19
3.2.4.3	Determination of lipid	19
3.2.4.4	Determination of crude fibre	20
3.2.4.5	Determination of ash	20
3.3	Statistical analysis	20
<b>4</b>	<b>IMPROVEMENT TO PELLET CHARACTERISTICS AND SUBSEQUENT EFFECTS ON GROWTH AND PHYSIOLOGY OF TILAPIA (<i>Oreochromis spp</i>) BY NATIVE AND PRE-GELATINIZED CARBOHYDRATES</b>	<b>21</b>
4.1	Introduction	21
4.2	Material methods	22
4.2.1	Formulation of diets	22
4.2.1.1	Proximate analysis	23
4.2.1.2	Carbohydrate analysis	23
4.2.1.3	Fatty acid analysis	24
4.2.2	Pellet characteristics	25
4.2.2.1	Bulk density (BD)	25
4.2.2.2	Expansion ratio (ER)	25
4.2.2.3	Pellet durability index (PDI)	25
4.2.2.4	Water absorption index (WAI) and water solubility index (WSI)	25
4.2.2.5	Water stability	26
4.2.2.6	Microstructure	26
4.2.2.7	Protein solubility	26

4.2.3	Tilapia, Oreochromis spp	27
4.2.3.1	Animal source and experimental design	27
4.2.3.2	Plasma biochemistry	27
4.2.3.3	Muscle proximate	28
4.2.3.4	Intestinal short chain fatty acids (SCFA)	28
4.2.3.5	Liver histopathology	28
4.2.3.6	Cholesterol	28
4.2.3.7	Fatty acid	29
4.3	Results	30
4.3.1	Experimental diets	30
4.3.1.1	Formulation of diets, proximate and carbohydrate analysis	30
4.3.1.2	Fatty acid analysis	31
4.3.2	Pellet characteristics	32
4.3.3	Tilapia, Oreochromis sp	36
4.3.3.1	Growth, survival, and feeding efficiencies	36
4.3.3.2	Whole body proximate, muscle cholesterol and body indices	37
4.3.3.3	Plasma biochemistry	37
4.3.3.4	Muscle fatty acid composition	38
4.3.3.5	Liver histopathology	40
4.3.3.6	Intestinal short chain fatty acid (SCFA)	42
4.4	Discussion	44
4.5	Conclusion	46

5	<b>COMBINATION OF PRE-GELATINIZED TAPIOCA STARCH AND ISOMALTOOLIGOSACCHARIDES ON THE PELLET CHARACTERISTICS AND SUBSEQUENT EFFECTS ON THE FEEDING EFFICIENCIES AND NUTRITIVE VALUE OF AFRICAN CATFISH, <i>Clarias gariepinus</i></b>	47
	5.1 Introduction	47
	5.2 Material and methods	49
	5.2.1 Formulation of diets	49
	5.2.1.1 Proximate analysis	50
	5.2.2 Pellet characteristics	50
	5.2.3 African catfish, <i>Clarias gariepinus</i>	51
	5.2.3.1 Animal source and experimental design	51
	5.2.3.2 Plasma biochemistry	51
	5.2.3.3 Muscle proximate	52
	5.2.3.4 Intestinal short chain fatty acids (SCFA)	52
	5.2.3.5 Liver histopathology	52
	5.2.3.6 Cholesterol	52
	5.2.3.7 Liver digestive enzyme	53
	5.3 Results	53
	5.3.1 Experimental diets	53
	5.3.1.1 Formulation of diets and proximate analysis	53
	5.3.2 Pellet characteristics	54
	5.3.3 African catfish, <i>Clarias gariepinus</i>	58
	5.3.3.1 Growth, survival, feeding efficiencies and hepatosomatic index	58
	5.3.3.2 Muscle body proximate	58
	5.3.3.3 Plasma biochemistry	59
	5.3.3.4 Intestinal short chain fatty acid	60
	5.3.3.5 Liver histopathology	61
	5.3.3.6 Liver digestive enzyme	62

5.4	Discussion	64
5.5	Conclusion	69
<b>6</b>	<b>GENERAL DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS</b>	<b>70</b>
	<b>REFERENCES</b>	<b>72</b>
	<b>BIODATA OF STUDENT</b>	<b>81</b>
	<b>LIST OF PUBLICATION</b>	<b>82</b>



## LIST OF TABLES

Table	Page
4.1 Feed formulations in percentage.	23
4.2 Ingredient formulation (g) and proximate composition (% dry weight) of the experimental diets.	30
4.3 Fatty acid composition (%) of the experimental diets	31
4.4 Physical properties of the extruded pellets with different pre-gelatinized or native carbohydrates sources.	32
4.5 Growth performance and feeding efficiencies of tilapia fed diets with different pre-gelatinized or native carbohydrate sources.	36
4.6 Whole body proximate composition (% wet weight), muscle cholesterol ( $\mu\text{g ml}^{-1}$ ) and body indices of tilapia fed diets with different pre-gelatinized or native carbohydrate sources.	37
4.7 Plasma biochemistry ( $\text{mmol l}^{-1}$ ) of the muscle from tilapia fed diets with different pre-gelatinized or native carbohydrate sources.	38
4.8 Fatty acid composition (%) of the muscle from tilapia fed diets with different pre-gelatinized or native carbohydrate sources.	39
5.1 Feed formulations in percentage	50
5.2 Ingredient formulation (g) and proximate composition (% dry weight) of the experimental diets.	53
5.3 Physical properties of the pelletized pellets whether native or pre-gelatinized tapioca starch with or without Iso-maltose.	55
5.4 Mean ( $\pm\text{SE}$ ) growth performance, feeding efficiencies and hepatosomatic index (HSI) of African catfish ( <i>Clarias gariepinus</i> ) juveniles fed diets with native and pre-gelatinized tapioca starch with or without Iso- maltose.	58
5.5 Mean ( $\pm\text{SE}$ ) proximate composition (% wet weight) of African catfish ( <i>Clarias gariepinus</i> ) juveniles fed diets with native and pre-gelatinized tapioca starch with or without Iso- maltose.	59
5.6 Mean ( $\pm\text{SE}$ ) plasma biochemistry parameters in African catfish ( <i>Clarias gariepinus</i> ) juveniles fed diets with native and pre-gelatinized tapioca starch with or without Iso- maltose.	59



## LIST OF FIGURES

Figure		Page
4.1	Surface structures of a) native corn starch, b) pre- gelatinized corn starch, c) native tapioca starch and d) pre- gelatinized tapioca starch at magnification $\times 30$ .	33
4.2	Cross section structures of a) native corn starch, b) pre-gelatinized corn starch, c) native tapioca starch and d) pre- gelatinized tapioca starch at magnification $\times 40$ .	34
4.3	Surface structures of a) native corn starch, b) pre- gelatinized corn starch, c) native tapioca starch and d) pre- gelatinized tapioca starch at magnification $\times 250$ .	35
4.4	Tilapia fed with the a) native corn starch, b) pre- gelatinized corn starch, c) native tapioca starch and d) pre- gelatinized tapioca starch after the Periodic- acid Schiff staining at magnification $\times 20$ .	41
4.5	PAS staining intensity.	42
4.6	Intestinal short chain fatty acids (SCFA)	43
5.1	Surface structures of a) native tapioca starch, b) native tapioca starch with Iso- maltose, c) pre- gelatinized tapioca starch and d) pre- gelatinized tapioca starch with Iso- maltose at magnification $\times 30$ .	56
5.2	Surface structures of a) native tapioca starch, b) native tapioca starch with Iso- maltose, c) pre- gelatinized tapioca starch and d) pre- gelatinized tapioca starch with Iso- maltose at magnification $\times 250$ .	57
5.3	Intestinal short chain fatty acids (SCFA).	60
5.4	African catfish fed with the a) native tapioca starch, b) Native tapioca starch with Iso- maltose, c) pre- gelatinized tapioca starch and d) pre-gelatinized tapioca starch with Iso- maltose after the Periodic- acid Schiff staining at magnification $\times 20$ .	61
5.5	Periodic- acid Shciff staining intensity.	62
5.6	Liver enzyme activity.	63

## LIST OF ABBREVIATIONS

ANOVA	Analysis of variance
FCR	Food conversion ratio
PG	Pre- gelatinized
g	Gram
h	Hour
H <sub>2</sub> SO <sub>4</sub>	Sulfuric acid
IUCN	International Union for Conservation of Nature
ind	Individual
kg	Kilogram
L	Liter
Min	Minute
Mg/L	Milligram per liter
ml	Milliliter
NaOH	Sodium hydroxide
pcs	Pieces
PER	Protein efficiency ratio
ppm	Part per million
PDI	Pellet durability index
WS	Water stability
BD	Bulk density
PS	Protein solubility
WAI	Water absorption index
WSI	Water solubility index
SE	Standard error
SGR	Specific growth rate
Sp.	Species
UPM	Universiti Putra Malaysia
USA	United States of America
°C	Degree Celsius
%	Percentage
<	Less than
>	More than

## CHAPTER 1

### INTRODUCTION

#### 1.1 Background of study

The main sources of energy in most animal diets are carbohydrates. The carbohydrates can be classified based on the structure, composition, constituent sugars and degree of polymerisation. It also can be classified based on the glycosidic linkage such as non-monomer carbohydrates like oligosaccharides which is lactose and maltose, polysaccharides which is starch, chitin and cellulose, and the other one is monomer sugars like glucose and fructose (Englyst, 1996). Carbohydrates properties are the vital importance for their nutritional effects. For example, the absorption rate and digestion, the viscosity, structural features fermentation ability in the gastrointestinal tract and water binding capacity (Asp, 1996).

The energy storage nutrient is starch. For example in wheat, approximately 60% of the total grain is a starch which is used as energy storage nutrient and constitutes (Novus, 1992), where the glucose molecules linked together by  $\alpha$ -glycosidic bonds is composed and the enzymatic activities in fish are influenced. Several fish species appeared to produce positive effects on digestibility and growth by the inclusion of dietary carbohydrate (Li *et al.*, 2013). There might have negative effects on growth, health, metabolism and nutrient utilization with the inappropriate amount of carbohydrates in aquafeed (Li *et al.*, 2012).

There are several factors like types, environmental conditions and source of carbohydrate that varies with the digestion and metabolism of carbohydrates digestion and in addition of fish species as well (Hutchins, 1998). Generally fish species that utilized carbohydrates more efficiently is warm water fish. They can utilize at higher levels than cold water fish and marine fish species (Wilson, 1994). As well high dietary levels of carbohydrates are efficiently utilized by the omnivorous fish species compared to carnivorous fish species (Enes *et al.*, 2011). So far, the dietary carbohydrate level has been not particularly defined.

#### 1.2 Significant of study

The most abundant and inexpensive sources in formulated feed are carbohydrates. It also can be easily available. Several fish species can utilize it efficiently as well (Zhao, 2011). Other than that, Azaza, 2013 found that there is protein sparing effects in tilapia and salmonid fish species when fed with carbohydrates. The most expensive ingredients are protein in the formulated aquafeed, and thus increasing the cost of the feed production. Starch is the well utilized carbohydrates source in aquafeed which can reduced cost of production and as well been used as a binder in feed. Reduced in cost of production is not only because the starch is inexpensive and it spare protein but it also influenced the pellet characteristic. In where, gelatinized starch improved the pellet characteristics.

### **1.3 Problem statement and hypothesis**

Starch is a carbohydrate made up of glucose units linked together by glycosidic bond and the most used carbohydrates sources in aquafeed. Utilization of carbohydrates is much more variable. It is probably related to natural feeding habits of the fish. Pelleting quality of the diet and the fish growth might have the benefit by the incorporation of the carbohydrate (Wilson, 1994). Usually native starch will be used in producing the aquafeed. Pre- gelatinized starches are rarely used and the characteristic of pre- gelatinized starches are unknown. Pre- gelatinized starches are more potential in growth and characteristic of the pellets compared to the native starches.

### **1.4 Research objective**

The general purpose of this study was to examine the potential differences between native starches and pre- gelatinizes starches. The specific objectives were:

1. To assess the potential differences of native and pre- gelatinized starches (corn starch and tapioca starch) on the pellet characteristic when extruded.
2. To assess the potential differences of native and pre- gelatinized starches (corn starch and tapioca starch) when extruded on the growth and various physiological parameters of tilapia.
3. To assess the potential differences of native and pre- gelatinized tapioca starch with and without prebiotic on the pellet characteristic when cold pelleted.
4. To assess the potential differences of native and pre- gelatinized tapioca starch with or without prebiotic on the growth and various physiological parameters of African catfish when cold pelleted.

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## BIODATA OF STUDENT

Nagakanmani D/O Muniandy was born at Temerloh District, Pahang. The district is well known as 'Temerloh Bandar Ikan Patin'. She completed her primary school at Sekolah Kebangsaan Kuala Kaung (1996- 2001), Lanchang. Then she went to Sekolah Menengah Kebangsaan Datuk Bahaman (2002-2006), Lanchang for her secondary school. At the secondary school she finds that Science and Mathematics as her loved subjects and she grow the most interest in it. She successfully completed her Sijil Pelajaran Malaysia (SPM) on 2006 and continued with the Sijil Tinggi Pelajaran Malaysia at Sekolah Menengah Kebangsaan Mentakab (2007-2008), Mentakab.

In 2009 until 2013 she have been continued her study in Bio-industrial technology at Universiti Malaysia Kelantan. She had been graduated in Bachelor of Science (Hons) in Bio- industrial Technology successfully on 2013. While she pursuing her degree, her interest was to help her father in farming. Her family background was from the agriculture sector, so that she eagerly wants to help the farmers to produce the productive product and supply a good product to the community.

## LIST OF PUBLICATION

**Kanmani. N**, Romano. N, Ebrahimi. M, Amin. S. M. N, Kamarudin. M. S, Karami. A and Kumar. V. 2017. Improvement of pellet characteristic by dietary pre-gelatinized starch and their subsequent effects on growth and physiology in tilapia. *Food Chemistry*, 239. 1037-1046.

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