GEWANG (*Corypha utan* Lam.) AS LOCAL FOOD IN TIMOR ISLAND AND ITS NUTRITIONAL PROPERTIES

JokoRidho Witono[1], Yayan Wahyu Candra Kusuma[1], Beth Paul Naiola[2], Yuliasri Jamal[2], Andria Agusta[2]

[1] Center for Plant Conservation-Bogor **Botanical** Garden, LIPI
Bogor 16003

[2] Botany Division-Research Center for **Biology,** LIPI
Cibinong, Bogor

ABSTRACT

Gewang (*Corypha utan* Lam.] is a palm species which grows in the dry land and is distributed from North-east India to North Australia. **Almost** the whole **part** of that **species has** been utilized by Timor Island villagers for daily needs such as building construction, handicraft, animal fodder, alcohol beverages, sugar, and food. **As** food, **gewang** starch is extracted from its **trunk.** Before that starch is consumed, it is cooked with shredded coconut, named as"akarbilan" or "puta' laka". This food becomes common **food,** especially in isolated area in Tirnor Island. Based on our analyses, nutrient content of 100 gr gewang starch is **as** follow: 11.995 g water, 0.518 g ash, 0.202 g fat, 0.691 g protein, 86.594 g carbohydrate, 32.726 g amylose, 51.11 g amylopectin, 12.278 g glucomannan, 100.52 mg calcium (Ca), 136.74 mg phosphorus (P), 3.390 mg iron **(Fe),** 0.108 **mg** vitamin B1. These results suggest those **gewang** starch nutrient contents are almost similar to sago starch, extracted from sago palm (*Metroxylon sagu*). In the future, investigation of gewang starch on their physical characteristics, non-nutritient properties, and processing should be carried out. Prospectively, **gewang** can to be used as food alternative, especially in dry land area such as Timor Island and adjacent regions in order to build food security in Indonesia.

Keywords:gewang, food, nutrients, Timor Island

INTRODUCTION

Gewang or talipot palm (*Corypha utan* Latn.) is palm species which grows in dry land and is distributed from North-east India to North Australia. This species is wild and spreading widely in East Nusa Tenggara savana. The cultivation of this species has not been done yet.

Gewang is very tall solitary palm (~ 15 m) with a broad trunk (–50 cm accross), tapering, faintly marked with closely-spaced hoops, and with a faint spiral mark. The crown of that species is very large fan-shaped leaves, 3 m across and the massive petiole is being edged with teeth. Gewang can be grown in subtropical and tropical climates with adequate sun, moisture, and space, The species has very large inflorescence which grows at the very top of the mature tree with stiff spreading branches. It produces millions of flowers and dies after the seeding cycle is complete. Rounded fruit diameter is ~ 2 cm and seed diameter is ~ 1.5 cm (Ellison and Ellison, 2001; Gibbons, 1998; Whitmore, 1973).

Like other species in genus *Corypha*, gewang is associated with human settlements. Almost the whole part of gewang has been utilized for daily needs by villagers in Timor Island, varied from building construction, handicraft, animal fodder, alcohol beverages, sugar and food. The gewang starch, used as food, is extracted from its trunk (Naiola *et al.*, 2007; Uhl and Dransfield, 1987).

Worldwide consumers have faced the rising of food price. On 24 March 2008, CNN stated that food prices are rising across the world because of freak weather and dramatic changes in the global economy, such as higher oil prices, lower food reserves and growing consumer demand in China and India. In long term, food prices are expected to be stable as farmers will grow more grains either for fuel or food. This will bring grain prices down. It is happened in United States, Canada and Europe in 2009 as they grew more wheat-crops. However, FAO projects reported that consumers still face more expensive food at least until 2018. It is rare that the spikes are hitting all major foods in most countries at once. In USA, food prices rose 4% in 2007, which was the highest price since 1990. In December 2007, tirthy seven countries faced food crises, and 20 countries of those had imposed some sort of food-price controls. In the 1990s and 1980s,

farm subsidies and support programs allowed major grain exporting countries to hold large surpluses, which could **be** tapped during food shortages to keep prices down. But new trade policies have made agricultural production much more responsive to market demands--putting global food reserves at their **lowest** since 1983.

Indonesia will also **face** food crises if their agriculture intensification and extensification programs could not provide national food demand in the future. **The** Government of Indonesia Republic had placed the identification and development of food alternative as an important issues in Medium Term Development Plan (RPJM) 2005-2009 and it **has** been **continued** to RPJM 2010-2014. One of gewang starch prospective is as **food alternative**

MATERIALS AND METHODS

Materials

In this study, gewang starch was extracted from six samples, **3** samples were **collected** from Fatubesi Village, Manulea Disctrict, **Belu** Regency and other 3 samples from Oele'u **Village,** Ayatupas District, Timor Tengah **Selatan** Regency. **Gewang** starch extraction was done by villagers and its extracting process was documented by the investigators.

Methods

The nutrient contents of gewang starch **are** fats, proteins, carbohydrates, amylose, amylopectin, glucomannan, **minerals** such as calcium (Ca), phosphorus (P), **iron** (Fe) and vitamins such as **A and** B1, were analyzed **using** these **methods** as listed in Table **1.**

Table 1. Methods of **analysis** of **gewang starch**

No.	Nutrititonal conte	Analysis Method	Refference
1	Water	Drying in 100°-105° C	Jacobs, 1959; Osborne and Voogt, 1978; Slamet *et al.*, 1990
2	Ash	Drying in 6000-6500 C	AOAC, 1984; Osborne and Voogt, 1978; Slamet *et al.*, 1990
1	Fats	Soxhlet	Jacobs, 1959; Slamct *et al.*, 1990
2	Proteins	Kjeldahl	AOAC, 1990; Jacobs, 1959; Osborne and Voogt, 1978; Slamet et *al.*, 1990
3	Carbohydrates	Spectrophotometry	Slamet *et al.*, 1990
4	Amylose	Spectrophotometry	Apriyantono et *al.*, 1988
5	Amylopectin	Spectrophotometry	Apriyantono *et al.*, 1988
6	Gtocomannan	H P L C	AOAC, 1984
7	Calcium (Ca)	A A S	AOAC, 1984
8	Phosphorus [P)	A A S	AOAC, 1984
9	Iron (Fe)	A A S	AOAC, 1984
10	Vitamin A	H P L C	AOAC, 1984
11	Vitamin B1	H P L C	AOAC, 1984

RESULTS AND DISCUSSION

Food is **any substances that** can be **eaten** or drunk by human **either for nutrient needs or pleasure.** (http://en.wikipedia.org/wiki/Food). **Almost** all foods are from **plants** or **animals** origin. Many plants or **plant** parts **are** eaten **as food.** About 2,000 plant species are **cultivated** for food source and many of them have several distinct **cultivars** (McGee, 2004).

Starch is the **most** important carbohydrate source in the human **diet. Starch have Iong been used** in food products such as noodles and other **wheat-based foods, fish crackers,** baby **foods,** bread dough **conditioners, ice** cream **stabilizers,** and soup and sauce thickeners (Abd Elgadir *et al.*, 2009). Mostly, **starch that is** used for **food,** is ussually **derived** from cereals (corn, **wheat, rice,** sorghum), tubers (potato, **sweet** potato), roots (cassava), legumes (mung bean, green pea) and **sago** palm (Karim *et al.*, 2008). **As** a sister lineage of sago

palm (*Metroxylon sagu),* gewang is also highly potential to be used as starch source.

The trunk of gewang contains a **yellowish** starch. In Malaysia, **a single gewang** tree can **be extracted** to **get 100 kg starch** (Whitmore, 1973) and in Philippines is 90 **kg starch (Nasution and** Ong, 2003). whereas **in Timor** Island **(Indonesia)** is **less** than 275 **kg** (Witono *et al.,* 2009). In Philippines, gewang is **the** third most important economic palm after coconut (*Cocos nucifera*) and nipah (*Nypa fruticans*) (Whitmore, 1973).

In Timor Island, gewang starch has been used **as food** source since long ago. **The** starch is consumed by baking it with **shredded** coconut, **known as** "akarbilan" or "puta' laka". **That** food is the most common diet for local people, especially in isolated area in Tirnor Island. During dry season, this food is consumed daily to replace the **rice** as rice **is** scarce and become an expensive **stuff** Traditionally, **gewang** starch is made by extracting its trunk. That **process** has several steps: **(1) cutting down gewang** palm, *(2)* removing bark of **the** trunk, **(3)** slicing inner trunk into small pieces, [4) drying inner trunk, [5) separating starch from the trunk fibre, traditionally using 'lesung' and 'alu' , **(6)** filtering the starch, (7) washing the starch and (8) **drying** the starch [Witono *et ab, 2009).*

Nutrients in food are **grouped** into **several** categories. Macronutrients **consists** of fats, proteins, and carbohydrates and micronutrients **are** the minerals and **vitamins.** Food also contains water and dietary fiber (http://en.wikipedia.org/wiki/Food). Each food has variation of nutrients and their amount. Based on our analyses, nutrient **values** of **gewang** starch are as follows:

Table 2. Nutrition properties of gewang starch [per 100 gr)

No.	Nutrition and other Substances	Sample						Gewang	Sago
		1	2	3	4	5	6	Starch	Starch
1	Water (%)	13.812	16.336	12.298	14.212	8.247	7.032	11.995	14.00**
2	Ash (%)	0.425	0.441	0.405	0.589	0.610	0.640	0.518	0.06-0.43**
3	Fat (%)	0.159	0 137	0.203	0.457	0.149	0.108	0 202	0.20**
4	Protein (%)	0.160	0.150	2.436	0.417	0.460	0 525	0.611	0.70**
5	Carbohydrate (%)	85.414	82.936	04.659	84.326	90.534	91.695	86.594	84 70**
6	Amylose [%]	29.33	na	32.78	33.47	34.04	34.01	32.726	21.31*
7	Amylopectin [%)	53.82	na	51.10	50.69	49.90	50 04	51.11	
8	Glucomannan (%)	0.51	na	11.39	17.11	17.11	15.27	12.278	
9	Calcium (mg)	59.90	87.60	58.10	139.79	128.84	128.70	100.52	11.00**
10	Phosphorus (mg)	24.75	19.75	93.09	226.42	228.27	228.15	136.74	13.00**
11	Fe (mg)	1.95	2.90	4.99	3.40	3.18	3.92	3.390	1.50**
12	Vitamin A (IU)	0	0	0	0	0	0	0	0**
13	Vitamin B1 (mg)	0.205	0.180	0.110	0.056	0.045	0.050	0.108	0.01**

Note: **Sample 1-3**: Fatubesi Village, Manulea Disctrict, Belu Regency; **Sample 4-6**: Oele'u Village, Ayatupas District,Timor Tengah Selatan Regency; *Ahmad *et al.* (1999), **Direktorat Gizi Departemen Kesehatan RI (1981).

Gewang starch contains fats, proteins, carbohydrates, amylose, amylopectin, glucomannan, Calcium (Ca), **Phosphorus** (P), Iron (Fe), vitamin A and B1 (Table 2). Fats **consist of a wide** group of compounds that **are** generally soluble in organic solvents and largely insoluble in water. **Fat** plays a vital role in maintaining healthy skin and hair, insulating organs **against shock,** maintaining body temperature, and **promoting** healthy **cell** function, Fats also serves as energy stores for the body, they are **broken down** in the body to release glycerol and free fatty acids. **The glycerol** can be converted into glucose by the **liver** and thus it is used as **a** source of energy (http://en.wikipedia.org/wiki/Fat). **Gewang** starch contains 0.202 gr fat per 100 gr. The amount **is equal** to **sago** starch (0.20 gr per 100 gr), whereas fat **in** wheat flour is 1.3 gr **and** rice flour **is 0.5** gr (Direktorat Gizi, Departemen **Kesehatan** RI, 1981). It means that **gewang starch is** potentially **used for diet program.**

Proteins are **organic** compounds made of **amino** acids, arranged in a linear chain and folded into a globular form. The polymer chain of amino acids are joined together by the peptide bonds between carboxyl and amino groups of adjacent amino acid residues. (Ridley, 2006). Proteins are building components for body tissues and cells, and **also a source** of energy for most organisms. The protein of gewang starch is almost equal to sago starch. which is 0.691 gr and 0.700 **gr** per 100 gr respectively.

Carbohydrates require less water to be digested compare to proteins or fats and are the most common source of energy in living things (http://en.wikipedia.org/wiki/Carbohydrate). Rased on heart disease and obesity risk, the institute of Medicine recommends American and Canadian adults to get 40-65% of dietary energy from carbohydrates (Food and Nutrition Board, 2005), whereas FAO and WHO obtained national dietary guidelines for energy from carbohydrate is 55-75% and 10% from sugars (simple carbohydrates) (Joint WHO/FAO expert consultation, 2003). Carbohydrates are inessential nutrients because human body can produce all its energy from proteins and fats. The gewang starch contains higher carbohydrate than sago starch which is **86.594** gr and 84.70 gr per 100 gr respectively. **As** alternative food, gewang starch **does** not have health **risks** such as heart disease and obesity, since it is consummed **without** any additional **food.**

Amylose can be made of several thousand glucose units. It is one of the two starch components which another component is amylopectin. Amylose is water soluble. Amylose starch is less readily digested than amylopectin; however, it takes up less space so it is preferred for storage in plants. It makes-up about 30% of the stored starch in plants, though the specific percentage varies by species. The digestive enzyme amylase breaks down the starch molecule into maltotriose and maltose. High-amylase varieties of rice have a much lower glycemic load, which could be beneficial for diabetics (http://en.wikipedia.org/wiki/ Amylose). Starch is produced as granules in most plants cells . It is referred to 'native' when it is in particular granular state. **Native** starches from different botanical sources are vary in structure and composition (http://www.cheng.cam.ac.uk/research/groups/polymer/ RMP/nitin/Starchstructure.html). Amylose composition in gewang starch is higher than sago starch which **is** *32.726%* and 24-31%

respectively. According to Ahmad *et al.* (1999), the difference of sago amylose content is most likely risen as a result of sago harvesting at different growth stages.

Amylopectin is water insoluble and consists of large-high-branched molecules, making up the majority of the plants' starch . Properties of amylopectin such as water solubility and bonding capacity make it more useful for technical applications in the food, paper, and chemical industries. The food industry also takes advantage of its properties. Usually, amylose and amylopectin must be separated or modified by chemical, physical, or enyzmatic. (http://www.gmo-safety.eu/en/glossary/). Starch is made of about 70% amylopectin by weight, though it varies depending on the source (http://en.wikipedia.org/wiki/ Amylopectin). However, gewang starch contains only 51.11% of amylopectin, so identification and further investigation on physical and functional characterization is necessary for food industry.

Clucomannan is a water-soluble polysaccharide that is considered as dietary fiber. Glucomannan is food additive used as an emulsifier and thickener. Clucomannan comprises 40% by dry weight of the konjact plant roots or corm of the konjact plant (*Amorphophallus konjac*) [http://en.wikipedia.org/wiki/Clucornannan). Clinical evidence suggests glucomannan may be beneficial for weight lass (Keithley and Swanson, 2005). Because it is a soluble fiber, it absorbs water to form viscous gel-like mass. This mass may promote satiety feelings while it is traveling through the gastrointestinal tract. In obese patients, taking 1 gram of glucomannan with 250 ml of water 1 hour before each of 3 meals daily over 8 weeks resulted 25 kg weight reduction in average (Walsh *et al.*, 1984). Gewang starch contains 12.278% glucomannan, so the starch is potentially used to reduce weight like konjact starch in japan.

Calcium is the fifth most abundant element by mass in the human body. Calcium is an important component of a healthy diet and necessary mineral for life because it plays important role in building stronger and denser bones in early life and keeping strong and healthy bones in later life. Calcium supplements are used to prevent and treat calcium deficiencies. Most experts recommend calsium supplements to be taken with food. The calsium suplements should be taken no more than 600 mg in one time because the

percentage of **calcium** absorbtion **will** decrease **as** the amount of calcium in **supplement** increases. Therefore, it is recommended to spread calsium dosage throughout the day. Recommended daily calcium intake for adults ranges from 1000 to 1500 mg and calsium supplements should be taken with food to increase calsium absorption **(http://en.wikipedia.org/** wiki/Calcium). Based on our analyses, gewang starch has more calcium than sago starch and other common staple food (Table 2 and ***see*** Direktorat Gizi Departernen Kesehatan **RI, 1981). Having** calcium 100.52 mg per 100 gr starch, gewang starch is potential to be used ***as*** calcium food additive.

Phosphorus is an essential **and** second most abundant mineral in the body after calsium. Eighty percent of phosphorus is found in bones **and** teeth. The other 20% works **in** body functions. The recommended **daily** allowance (RDA) of phosporus for adults is similar to calsium which is 800 mg. Pregnant or breastfeeding women should get 1200 mg phosphorus daily (http://www.healthopedia.corn/ phosphorus/]. Its functions is mostly with calcium, which needs proper utilization and healthy balance calcium-phosphorus is 2:1. **A** high phosphorus levels can interfere with calcium absorption. This can eventually lead to poor bone maintenance and osteoporosis, or brittle bones. *Excess* phosphorus can also interfere with the iron absorption. Phosphorus is not toxic since **it** is stored in the body, but long-term excessive use may result in inhibiting of calcium absorption (http://www.healthvitaminsguide.com/ minerals/phosphorus.htm). **As** a comparison, gewang starch contains high phosphorus (136.74 mg **per** 100 gr), whereas sago starch is **only** 13 **mg** per 100 gr. It might be caused by niche of each **species. Gewang grows** in the savanna of Timor Island with rich phosphorus soil, whereas sago palm **grows** in peat swamp forest with poor phosphorus **soil.** Phosphorus cornpotition **in gewang** starch ,extraded from gewang tree, from other regions might be low

Iron (Fe) **is** great important **in** human nutrition. The adult body contains iron between **3-4** gr and 60-70% of that iron is as circulating iron in the blood (Hb iron) and **the** rest **(1** to 1.5 **gr)** as iron storage. Iron is necessary for many **body** functions including haemoglobin formation, brain development and function, regulation of body temperature, muscle activity **and** catecholamine metabolism. Lack of iron will affects immune system, a decrease of circulating

haemoglobin concentration due to **impaired** haemoglobin synthesis and followed by nutritional anaemia. **Because** of iron recycling, the body **needs** only a small amount of iron. In general, **iron** requirements becomes greater during rapid tissue and red cell mass expansion, for example, during pregnancy, childhood and adolescence. iron requirement for different age groups is 0.7 mg for infants (5-12 months) , 1.0 mg for children (1-12 years), 1.8 mg for male adolescence (13-16 years) and 2.4 mg for females, and 0.9 mg for adults (http://www.healthvitaminsguide.com/minerals/iron.htm). Gewang starch contains 3.390 mg iron per 100 gr which is higher **more** than two folds **compare** to sago starch (1.50 gr per 100 gr). It means, consumming 27 gr of gewang strach could provide daily needs of adults iron requirements.

Vitamin A is fat-soluble **vitamin** and widely distributed in animal and plant foods. **Plants** is the cheapest source of vitamin A which is green **leafy** vegetables such as spinach **and** amaranth found abundance in nature throughout the year. The darker the green **leaves,** the higher the carotene content. Vitamin A is also available in most green **and** yellow fruits and vegetables (e.g. papaya, mango, pumpkin) and some roots (e.g. carrots). Vitamin A is essential for **growth.** It helps normal growth of bones and teeth, particularly in children **and young** people. As many other vitamins, certain amount **of** vitamin A is **needed,** but too much vitamin A is harmful for the health. [http://www.healthvitaminsguide.com/ vitamins/vitamin-a.htm). Not like sago starch, gewang starch does not have vitamin A. Therefore, additional food containing vitamin A is necessary for gewang starch when it is used as main food.

Vitamin B1 (thiamine) is water-soluble vitamin and known as anti beri-beri substance. Beriberi is disabling condition. It was endemic for centuries in Orient and Pacific islands and it was finally proved to be deficiency **disease.** The main source of vitamin B1 in Indian diet is cereals [rice and wheat), **which** contribute 60-85% of the total thiamine requirements. Thiamine in rice loose during milling. Further losses is taken place during washing and cooking the rice. Much thiamine in fruits and vegetables generally will loose during prolonged storage. Thiamine is destroyed in toasting and cooking cereals with baking soda. Thiamin increases the blood circulation, helps blood formation and carbohydrates metabolism. Most thiamine deficiency is due to the abnormal accumulation of

acids. Without thiamine, the cells cannot utilize oxygen or fuel for energy, the nervous system cannot function properly, and the muscles can not perform best. Thiamine toxicity is uncommon; as excessed thiamin is excreted. However, long-term thiamine supplementation more than **3** grams has been known causing toxicity. (http://www.healthvitaminsguide.com/vitamins/vi tamin-b1.htm). The thiamine content of selected foodstuff (mg/100 gr) *is* as follows: rice flour 0.12 mg, maizena **0.38 mg,** potato flour 0.04 mg, manihot starch 0.04 mg, sago starch 0.01 mg and **wheat** flour 0.12 mg (Direktorat Gizi, Departemen Kesehatan RI, 1981). Gewang starch contains 0.108 mg thiamine per 100 gr. It means the amount of thiamine in gewang starch is almost equal to rice flour and higher than **sago** starch.

The analyses showed that nutrition properties of gewang is almost similar to sago starch in general. The colour of gewang starch is white yellowish which indicates that some other components of gewang starch might be present. These components probably belong to antinutriotional component which will become impediment for gewang as food source. Antinutriotional component might not only be toxic, but also can **be** lethal in extreme situations (Bhat and Karim, 2009). Further investigation regarding to antinutritional analyses, physical and functional characterization should be done to obtain comprehensive information in order to develop **gewang** starch for food industry in the future.

CONCLUSION

Cewang starch has been used as food source since long ago. The starch is consumed by local people, especially in isolated area of Timor Island by additing shreded coconut and baking **it,** known as "akarbilan" or "puta' laka". It is consumed daily to replace rice during dry season where rice is scarce **and** become expensive. Based on our analyses, nutrition properties of 100 gr gewang starch as follows: water 11.995 g, ash **0.518g,** fat 0.202 g, protein 0.691 g, carbohydrate 86.594 **g,** amylose 32.726 **g,** amylopectin 51.11 g, glucomannan 12.278 g, Calcium (Ca) 100.52 mg, Phosphorus (P) 136.74 **mg,** Iron (Fe) 3.390 mg, Vitamin B1 0.108 mg. The results suggest that the nutrition value of gewang starch is almost similar to the sago starch,

extracted from **sago** palm (*Metroxylon* sagu). Further investigation regarding to antinutritional analyses, physical and functional characteristic of gewang starch should be done to obtain comprehensive information in order to develop gewang starch for food industry in the **future**

References

Abd Elgadir, M., J. Bakar, I.S.M. Zaidul, R. Abdul Rahman, K.A. Abbas, **D.M.** Hashim, and R. **Karim.** 2009. Thermal Behaviour of Selected Starches in Presence of other Food ingredients studied by differential scanning calorimetery (DSC)-Review. Comprehensive **reviews** in food science and food **safety** (8): 195-201.

Ahmad, F.B., **P.A.** Williams, J.L. Doublier, S. Durand, and **A.** Bul'eon. 1999. Physico-chemical characterization of sago starch. Carbohydrate Polymer 38(4):361-70.

AOAC. 1984. Methods of Analysis of the AOAC. 14th Edition. AOAC Inc., Arlington, Virginia.

AOAC. 1990. Official Methods of Analysis of the AOAC. 15th Edition. AOAC Inc., Arlington, Virginia.

Apriyantono, A., **D.** Fardiaz., N.L. Puspitasari, S. Yani, dan S. Budiyanto. 1988. Analisis Pangan. PAU-IPB, Bogor.

Bhat, **R. and A.A.** Karim. 2009. Exploring the nutritional potential of wild and underutilized **legumes.** Comprehensive Reviews in Food Science and Food **Safety** (8) :305-331

Direktorat Gizi Departemen Kesehatan RI. 1981. Daftar Komposisi Bahan Makanan. Penerbit Bhratara Karya Aksara, Jakarta.

Ellison, D. and **A.** Ellison. 2001. Cultivated Palms of the World. Periplus Editions (HK) Ltd. Singapore.

Food and Nutrition Board. 2005. Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino **Acids.** The National Academies Press. Washington DC.

Gibbons, M. 1998. Identifying palms: **The** new Compact **Study** Guide and Identifier. **Chartwell** Books, Inc. New jersey.

http://www.cheng.cam.ac.uk/research/groups/poymer/RMP/nitin/ Starchstructure.html. 2009. Composition and structure. **Accessed** November 15, 2009.

http://www.gmo-safety.eu/en/glossary/. 2009. **Accessed** November 15th, 2009.

http://www.healthopedia.com/phosphorus/. *2009.* Accessed November 15th, 2009.

http://www.healthvitaminsguide.com/minerals/phosphorus.htm. 2009. **Accessed** November 15,2009.

http://www.healthvitaminsguide.com/vitamins/vitamin-a.htm. 2009. Accessed November 15,2009.

http://en.wikipedia.org/wiki/Amylopectin. 2009. **Amylopectin. Accessed** November 15,2009.

http://en.wikipedia.org/wiki/ Amylose. 2009. Amylose. Accessed **November 15,2009.**

http://en.wikipedia.org/wiki/Calcium. *2009.* Calcium. **Accessed** November **15,2009.**

http://en.wikipedia.org/wiki/Carbohydrate. 2009. Carbohydrate. Accessed November **15,2009.**

http://en.wikipedia.org/wiki/GIucornannan. 2009. Glucomannan. Accessed November 15,2009.

http://en.wikipedia.org/wiki/Fat. 2009. Far. **Accessed** November 15th, *2009.*

http://en.wikipedia.org/wiki/Food. 2009. Food. **Accessed** November **15th, 2009.**

Jacobs, M.B. 1959. The Chemical Analysis of Food and Food Products. **3rd** Edition. D. Van **Nostrand** Co Inc., New York.

Joint WHO/FAO expert consultation. 2003. Diet, Nutrition and the Prevention of Chronic **Diseases** (PDF). World Health Organization. Geneva.

Karim, A.A., A. Pei-Lang Ti, D.M.A. Manan, and I.S.M. Zaidul. 2008. Starch from the Sago (*Metroxylon sagu*) Palm Tree-Properties, Prospects, and Challenges as a New Industrial Source for Food and other Uses. Comprehensive reviews in food science and food safety (7): 215-228.

Keithley, J. and B. Swanson. 2005. Glucomannan and Obesity: a Critical Review. Altern Ther Health Med 11(6): 30–4.

McGee, H. 2004. On Food and Cooking: The Science and Lore of the Kitchen. Simon and Schuster. New York.

Naiola, B.P., J.P. Mogea and Subyakto. 2007. Gewang: Biologi, Manfaat, Permasalahan dan Peluang Domestikasi. Pusat Penelitian Biologi-LIPI. Bogor.

Nasution, R.E. and H.C. Ong. 2003. Corypha utan Lam. in. Brink, M. and R.P. Escobin (Eds.). Fibre Plants. PROSEA No. 17. PROSEA Foundation. Bogor.

Osborne, D.R. and P. Voogt. 1978. The Analysis of Nutrients in Food. Acedemic Press. London.

Ridley, M. 2006. Genome. Harper Perennial. New York.

Slamet, D.S., M.K. Mahmud, Muhilal, D. Fardiaz and J.P. Simarmata. 1990. Pedoman Analisis Zat Gizi. Direktorat Bina Gizi Masyarakat dan Pusat Penelitian dan Pengembangan Gizi. Departemen Kesehatan RI. Jakarta.

Uhl, N.W. and J. Dransfield. 1987. Genera Palmarum: A Clasiffication of Palms based on the Work of Harold E. Moore, Jr. Allen Press and The International Palm Society. Lawrence, Kansas.

Walsh, D.E., V. Yaghoubian, and A. Behforooz. 1984. Effect of glucomannan on obese patients: a clinical study". International Journal of Obesity 8 (4): 289–293.

Whitmore, T.C. 1973. Palms of Malaya. Oxford University Press. London.

Witono, J.R., B.P. Naiola, Y. Jamal and Y.W.C. Kusuma. 2009. Eksplorasi dan kajian pemanfaatan gewang (*Corypha utan* Lam.) sebagai sumber tepung untuk bahan pangan. Laporan Kemajuan Kegiatan Tahap I Program Kompetitif LIPI Tahun 2009 (Periode 1 Februari s.d. 30 Juni 2009). Biro Perencanaan dan Keuangan LIPI and Pusat Konservasi Tumbuhan-Kebun Raya Bogor LIPI. Bogor.