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Study on Fatty Acid Composition and Amino Acid Content of Coconut Endosperm of Selected Coconut Cultivars in Thailand[1]

Wilaiwan Twishsri[2], Parinda Runheem[2], Seree Usathit[2],
Somchai Watanayothin[3] and Peyanoot Naka[3]

Abstract

The nutritive values of tropical fruits like coconut are of interest to consumers and useful for the breeding program. The two experiments were carried out in Completely Randomized Design with 3 replications. The first experiment aimed to determine the essential and non-essential amino acid content of liquid and solid endosperm of potential market varieties of coconut such as young tender nut of Aromatic Green Dwarf (Nam Hom) and mature nut of hybrid Nam Hom x Kathi (NHK). Among the 18 kinds of amino acids, the significant differences were found on Aspatic acid, Cystine, Serine, Isoleucine, and Phenylalanine content while highly significant differences were found on Histidine and Methionine content. The second experiment aimed to determine the fatty acid composition of virgin coconut oil of 20 coconut accessions from the coconut field gene bank of Thailand at Chumphon Horticultural Research Centre. The result showed that there were significant differences on the eight fatty acid compositions. Among the eight fatty acids, lauric acid is the most noted one by consumers and it was found that lauric acid content in virgin coconut oil (VCO) was excellent (lauric acid $\geq$ 48.8%) and the mean of lauric aicd content among the eight varieties had no significant difference at 5% level by DMRT. These varieties include including Renell Tall, Chumphon Hybrid No. 2, Malayan Yellow Dwarf, Sawi Hybrid No.1 (MAWA), Hybrid Chumphon 60, Thai Red Dwarf, Sri Lanka Tall, and Hybrid Nam Hom x Kathi (NHK) with the lauric acid content at 51.0, 50.1, 49.3, 49.0, 49.0, 49.0, 48.9, and 48.8%, respectively. These varieties, therefore, were suitable for VCO processing since they have high lauric content.

Keywords: coconut, amino acid, lauric acid

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[2] Chumphon Horticultural Research Centre, Sawi, Chumphon 86130, Thailand
Tel. 667 755 6073 Fax. 667 755 6026 Email: wpaenkhao@hotmail.com

[3] Horticultural Research Institute, Department of Agriculture, Chatuchak, Bangkok , Thailand 10900.
Tel. 662 561 4666 Fax. 662 561 4667

Introduction

Coconut study in Thailand

The Chumphon Horticultural Research Centre (CHRC) was known as the Coconut Field Gene Bank of Thailand. More than 20 coconut accessions were conserved in this research center. Since 1965, the CHRC research team has collected and studied the morphological traits of these collected coconut accessions and classified these into 2 groups; Dwarf and Tall varieties (Thirakul, 1979). The Thai coconut varieties which belong to Dwarf group are Patiu, Nok Khum, Thung Khled, Nam Hom, Thai yellow dwarf (Mu Si Laung and Na Like), Thai Red dwarf (Mu Si Som / Mu Si Daeng) and Maphrao Fai. While the coconut varieties belonging to Tall group are Kaloke, Tap Sakae, Nakorn Si Thammarat, Chumphon, Pak Chok, and Thalai Roi. Later, the CHRC research team succeeded in their coconut breeding program and released the 3 recommend hybrid varieties: namely, Sawi Hybrid No.1, Chumphon Hybrid No. 2, and Hybrid Chumphon 60 in 1982, 1987, and 1995, respectively. CHRC have produced and distributed the hybrid varieties to coconut farmers up to now. Recently, Thai coconut breeder succeeded in breeding program and brought about the two newly hybrid coconut varieties : namely, Hybrid Nam Hom x Kathi (NHK) and Malayan Yellow Dwarf x Kathi (YDK)**.** Moreover, the nutritive values of NHK such as calcium (83.3 mg/kg), Iron (2.13%), Phosphorus (0.03%), Protein (0.98 g/100g), Carbohydrate (9.24 g/100g), and Fat (10.69 g/100g) were identified (Watanayothin *et al*., 2010).

In view of utilization of coconut genetic resources, aside from characterization for morphometric traits for breeding program, the coconut accession should be studied to get useful information such nutritive values in order to support the use coconut varieties. Thus, in this study, some coconut varieties of the field gene bank were selected to determine fatty acid compositions and amino acids contents.

For the first experiment only two coconut varieties were collected as samples for amino acid determination since it was considered as the commercial potent for fresh consumption and also can be developed for food and non-food products. Therefore, these two coconut cultivars were selected to determine the amino acid contents in order to prepare basic information and support the coconut breeding program in Thailand as well as commercial sector.

It should be noted that the young tender nut of Aromatic Green Dwarf (Nam Hom) is commercial and export product from Thailand and the hybrid Nam Hom x Kathi (NHK) is the new hybrid varieties from the successful coconut hybrid program of the researcher (coconut breeder) of the Horticultural Research Institute (Watanayothin *et al*., 2010). This varieties had been certified by the Department of Agriculture, then it was named as Hybrid Chumphon 84-1. The later varieties become more popular and well known since it has unique pandan aroma the same as Nam Hom and has soft meat similar to Makapuno.

In the second experiment, the selected coconut cultivars were classified into 4 groups such as 1) Local Thai Dwarf varieties, 2) Local Thai Tall varieties, 3) Foreign varieties, and 4) Hybrid varieties. All of the mature nuts of these varieties can be used as raw material for VCO processing. The second experiment aims to determine the fatty acid composition of Virgin coconut oil of 20 coconut accessions at Chumphon Horticultural Research Centre.

Health benefits of coconut oil

The studies conducted in the past have revealed the beneficial results from the use of coconut oil. The study done by the medical researchers from the Michigan State University headed by Prof. Emeritus of Pharmacology, *John J. Kabara* found out that the lipids in mother's milk which give babies immunity from diseases is very similar in structure to the medium chain fatty acids (MCFA) which is predominantly present in coconut oil and have similar nutriceutical effect. This finding triggered the conduct of a series of studies that led to the discovery of the anti-microbial properties of

MCFA in coconut oil with lauric fatty acid and its monoglyceride from monolaurin as the most potent (Bawalan, 2009).

There are various studies which support the usefulness of coconut oil such as in *1992 Kaunitz and Dayrit* showed the positive effect of virgin coconut oil on health. The claim was supported by *Dan Eringthon* from Australian National University from their studies on Tuvalu civilization in South Pacific, in *1995 Mary Enig* found that virgin coconut oil was transformed to mololaurin during absorption from the intestinal epithelial cells. Lauric acid, the major fatty acid of VCO, has anti-virus property and perhaps for this reason it is gaining prominence in treatment even for AIDS, and in *2004*, *Nevin and Rajmohan* showed that virgin coconut oil lowered serum cholesterol, triglycerides, LDL cholesterol and elevated HDL cholesterol in comparison with refined coconut oil and groundnut oil. In *2006*, the same authors showed enhancement of antioxidant defense systems upon consumption of virgin coconut oil. This was attributed to polyphenols in coconut oil (Lokesh, 2007).

The coconut oil contains Lauric acid, Capric acid, Capryllic acid and Caproic acid which are the MCFA and the shorter chain fatty acids that allows to be metabolized without use of the carnitine transport system. When these acids are inside the body, they are transformed into corresponding monoglycerides namely monolaurin, monocaprin, monocaprylin, and monocaproin, all of which are able to kill the pathogenic microorganisms such as bacteria, fungi, yeasts, viruses and protozoa. They also provide immunity to the body. The lauric acid in coconut oil has long been recognized as disease fighting derivative monolaurin that the babies get from their mother's milk. Recently, capric acid, another ofcoconut's fatty acids has been added to the list of coconut's antimicrobial components (Enig, 1999).

Preliminary study on the effects of coconut oil on HIV+AIDS gave very encouraging results with subjects' viral load was dramatically reduced and immune system enhanced as reflected in the CD4/CD8 count (Dayrit, 2000).

Medical studies have shown that coconut oil possesses potent anti-cancer properties. It was experimented by feeding the animals' diets containing different types of fats, including coconut oil, to determine their influence on tumor development. Tumors developed in all tested rats (chemically induced colon cancer animals), except those that were fed with coconut oil. The researchers concluded that coconut oil protected the animals against tumor development (Reddy and Maeura (1984) cited by File, 2005). For a study on skin cancer, researchers found that when coconut oil was applied to the skin of test animals along with the cancer-causing chemicals, there was a complete absence of tumor development. In contrast to the application of cancer-causing chemicals, tumor developed within weeks (Nalasco *et al* (1994) cited by File, 2005). Coconut oil not only blocks the growth of cancer but aids the immune system in fighting it due to the MCFA in coconut oil inhibit tumor growth and stimulate the production of white blood cells, specially T-cells, which attack and kill anything that the body perceives to be harmful, including cancerous cells (Ling et al (1991); Wanten (2006); Witcher et al (1996) cited by File, 2005). Nair (2010) also reported that a recent study at the Skin Care and Cancer Foundation at Pasig, Philippines evaluated novel atibacterial and antimollient effects of VCO in patients with a skin condition called atopic dermatitis. Several applications of VCO stopped tumor development.

Coconut oil is known to protect human being against certain cancers. The coconut oil plays a vital role in discouraging the rogue cell from growing further, most rogue cells die a natural death in time. 50% of saturated fat in the coconut oil is lauric acid and 6-7% is capric acid which get converted to mono laurin and mono caprin in the human body. It kills viruses, many bacteria, and even protozoa like giardia Lamblia and monocaprin as powerful as the former laurin to kill all kinds of germs (Hedge, 2009). However, he suggested that the total fat intake should not form more than 20% of our total calorie requirement per day due to 90% if our serum cholesterol is manufactured in our own

livers to help keep us alive and only 10% comes from the food, a very small contribution indeed.

Besides, the clinical studies done at the New England Deaconess Hospital (NEDH), a Harvard medical school affiliate, showed that coconut oil is neutral in its effect on blood lipids and will not cause an increase in cholesterol or cause cardiovascular disease (Norton et al., 2004 cited by Carandang, 2008). Many animal experiment shows beneficial or harmless effects of coconut oil consumption. Coconut oil feeding produced significantly higher alpha lipoproteins (HDL) relative to sunflower oil feeding in rats (Host mark *et al* (1980) cited by Ghosh *et al*, 2008). To prove the myth of consuming the coconut oil with saturated fat cause heart disease, Vasudevan (2010) has studied lipid profile in blood and plaque material from disease coronary artery of from coconut oil consuming population versus sunflower oil consuming population. The result from his analysis showed that there was no statistically significant difference in cholesterol, HDL or LDL levels in the serum token from both groups. He concluded that the plasma fatty acid composition reflected no changes with dietary fat source. He have also analyzed the fatty acid composition of the plaques taken from diseased coronary arteries, it was seen that plaques from coronary artery did not contain fatty acids from coconut oil. Fatty acid content of the plaques from coconut oil consuming group and sunflower consuming group were the same. He concluded that the coconut oil does not have any effect on plaque formation or heart disease (Vasudevan, 2010). In addition, the effect of VCO in lowering of cholesterol in the body was studied and conducted by the University of Santo Tomas Research Center for Natural and Applied Sciences with 189 local inhabitants; 110 participants took 3 tablespoons of VCO every day while 79 others had a placebo drug for 4 months. Results indicated decreases in triglycerides and very low density lipoprotein (VLDL), which is considered bad chloresterol, and elevated high density lipoprotein (HDL), which is considered good chloresterol, among the VCO takers. No change was seen in low density lipoprotein (LDL) (Alave, 2012).

At present, the fatty acid composition of coconut oil has gained a lot of attention since there is a great deal of research and commercial interest in coconut products and coconut oil, especially, Virgin Coconut Oil (VCO) which has many applicantions and a source of medium chain triglyceride which can be used as nutritional supplement (Chomchalow, 2010). It improves energy absorption for many elements and vitamins such as, A, B, E, K, D. According to File (2012), the researchers from Auburn university experimented on vitamin B deficient rats by giving different type of fats. They found that coconut oil was the most efficient in preventing the disease and extending the lifespan. A number of studies over the years have found similar effects. Coconut oil improves the absorption of not only B vitamins but also vitamins A, D, E, K, beta-carotene, CoQ10 and other fat soluble nutrients, minerals such as calcium, manganese, and some amino acids.

Coconut oil can give great benefit to diabetics. The MCFA in coconut are small enough that they don't need the aid of insulin in order to enter cells. Studies have shown that coconut oil helps regulate blood sugar because MCFA improve insulin production and insulin sensitivity (Garfinkel *et al.* (1992); Hand *et al.* (2003) cited by File, 2005), in other words, coconut oil helps the body produce insulin and reverses insulin resistance, thus relieving many of symptoms associated with diabetes (File, 2005).

Newly information was reported that consumption of coconut oil can increase blood ketone levels to therapeutic levels that can successfully treat all of neurological disorders such as Alzheimer's disease, Parkison's disease' Huntington's disease, ALS, stroke, narcolepsy, brain trauma, and brain cancers. Studies showed that MCTs can effectively mitigate the effect of Alzheimer's (File, 2012), as ketones produced from MCTs act as a superfuel. They not only provide a high quality source of energy for the brain but trigger the activation of special proteins that function in brain cell maintenance, repair, and growth, thus providing a therapeutic effect on the brain.

In this study, therefore, the mature nuts of selected coconut varieties were harvested to produce VCO then the fatty acid composition, and the fatty acid content as well as lauric acid content were examined. The amount of lauric acid content will be used to identify the suitable raw material coconut varieties for VCO production.

Objective

The purpose of this study is

(1) to determine the amino acid content of selected potential coconut varieties in order to support the nutritive value for commercial purpose and

(2) to determine fatty acid composition of coconut accession in order to identify the coconut varieties that suit to be raw material for VCO production .

The result of this study can be used as initial information for coconut breeders to select mother palms for breeding program, and for VCO processors to choose coconut varieties for VCO production.

Materials and Methods

Material

1. Young and Mature nuts of Aromatic Green Dwarf
2. Mature nuts of Hybrid Nam Hom x Kathi (NHK)
3. Samples of VCO from each coconut varieties

Equipments

1. Hot air oven for preparation of dried grated coconut
2. Hydraulic press machine for making VCO
3. plastic bottle for carrying VCO to laboratory
4. Styrofoam Box for maintain chilled temperature to prevent spoilage while carrying the samples to laboratory

Methods

1. Preparation and determination of coconut sample for amino acid content

The coconut samples such as young tender nuts of Aromatic Green Dwarf (Maphrao Nam Hom) and mature nuts of Hybrid Nam Hom x Kathi (NHK) were collected from Khanthulee Coconut Seed Garden, Ta Chana district, Surat Thani province, then the samples were taken to postharvest laboratory of Chumphon Horticultural Research Centre. The experiment was designed as Completely Randomized Design (CRD) with 3 replications and 5 treatments of sample preparations such as 1) coconut meat of NHK at 12 months old, 2) coconut meat of young tender nut of Nam Hom at 7 months old, 3) coconut water of NHK at 12 months old, 4) coconut water of young tender nut of Nam Hom at 7 months old, and 5) coconut water of mature nut of Nam Hom at 11 months old. 10 to 15 nuts of each varieties were collected for one replication. The nut was opened and coconut water were separated from the meat. For the coconut meat, ¼ of nut from top to bottom were collected from each nut, chopped into small pieces and samples of 15 nuts were mixed then sampling for 1 kg of sample was done. The coconut water was mixed and packed in plastic bags. The packed and chilled samples of coconut meat and coconut water were placed in iced styrofoam box and sent to the Laboratory, Institute of Food Research and Product Development, Kasetsart University. The coconut samples were analyzed for amino acid content by T-CM-006 Based on Journal of Chromatography A (2002). 961 : 9-21.

2. Preparation and determination of virgin coconut oil (VCO) for fatty acid composition

The mature nut at 11-12 months old, 20-25 nuts per varieties of each coconut varieties from 20 coconut varieties / accessions were harvest from CHRC and NHK was harvested from Khanthulee Coconut Seed Garden, Ta Chana district, Surat Thani province. The coconut meat was taken out and ground then dry in hot air oven for 1 hours at 70^0C and 3 hours at 65^0C. The dried and white meat was pressed by

hydraulic to obtain the VCO then filtered. The VCO was packed in plastic bottle and sent to the Laboratory of Department of Science Service, Bangkok. This experiment was designed as Completely Randomized Design (CRD) with 3 replications of set of sample preparations and 21 treatments (20 coconut varieties). It should be noted that the Kaloke varieties was splited into two treatments based on nut size.

Results and Discussion

Experiment I.

As we all may knows that amino acid is the smallest unit of protein structure. There are 20 amino acids in human being. Lacking or limited of amino acid consumption will affects human function such as lack of hormone function and elastic muscular function, etc. Amino acids can be divided into 2 groups such Essential amino acids and None essential amino acids. There are 9 Essential amino acids found in coconut such as Isoleucine, Leucine, Lysine, Methionine, Phenylalanine, Threonine, Tryptophan, Valine, and Histidine. While the 9 None-essential amino acids such as Alanine, Arginine, Aspatic acid, Cystine, Glutamine, Glycine, Proline, Serine, and Tyrosine**.** However, Arginine can be classified as a semi-essential or conditionally essential amino acid, depending on the developmental stage and health status of the individual. The percentage of areginine, alanine, glutamate, aspartate, cystine and serine is higher in tender coconut water and among these L-arginine constitutes the major. The major factor responsible for the hypolipidemic and cardioprotective effect of tender coconut water is mainly due to the high amount of L-arginine (Raiver and others (1997) cited by Anurung et. al, 2007). The cardioprotective effect of L-arginine is mediated by L-arginine nitric oxide pathway (Prenow and Wang (1999) cited by Anurung et. al, 2007).

In the first experiment, the essential and non-essential amino acid contents of liquid and solid endosperm of potential market varieties of coconut such as young tender nut of Aromatic Green Dwarf (Nam Hom) and mature nut of Hybrid Nam Hom x Kathi (NHK) were studied. It was found that among 18 kinds of amino acids (Table 1), the significant differences were found on Aspatic acid, Cystine, Serine, Isoleucine, and Phenylalanine content while highly significant differences were found on Histidine and Methionine contents. Most amino acid content was found in T1 (coconut meat of NHK at 12 months old) and T2 (coconut meat of young tender nut of Nam Hom at 7 months old) are more than others, therefore, the coconut meat has higher amino acid content than coconut water.

Compared to the previous study, the free amino acids content in coconut water in the ripening nut increased from 4 mg/100ml to 16 mg/100ml whereas its concentration in the kernel decreased (Pillai *et al*., 1959 cited by Rethinam, 2006), the coconut water of NHK at 12 months old (T3) and mature nut of Nam Hom at 11 months old (T5) has greater amount of amino acid than normal ripening nut as their studied report (table 1).

Besides, the amino acids found in this study are similar to the study done by Novarianto and others (2006) from the Indonesian Coconut and Palmae Research Institute (ICOPRI) in relation to amino acid contents in 3 dwarf and 3 tall coconut varieties found that there are 10 kinds of amino acids in coconut kernel such as Histidine, Threonine, Arginine, Methionine, Valine, Phenylalanine, Tyrosine**,** Isoleucine, Leucine, and Lysine. However, the result from this study shoes that there are 18 amino acids which is found in line with the report of Woodroof (1997) which revealed that coconut has also Alanine, Argentine, Cystine, and Serine. These four amino acid content is even higher than those found in cow milk.

Previous literatures stated that coconut water contains small amount of protein. The nitrogen and total protein content of coconut water increased gradually with maturation (Chikkasubbanna *et al*., 1990 cited by Rethinam, 2006). The protein content of coconut water increases while the one in the kernel decreases at 8^{th} month of maturity (Shivasankar, 1991 cited by Rethinam, 2006). Most coconut cultivars have maximum free amino acid content in water

at 7th month of maturity (Poduval *et al*., 1998 cited by Rethinam, 2006). When compared the above result with this study, it was found that the 10 of 18 amino acids content in coconut water of Nam Hom varieties at young tender nut of 7 months old (T4) is greater than the mature nut at 11 months old (T5). However, it was not significantly different at 5% level by DMRT.

Although amino acid content in coconut is lesser than other crops, they will not lose in certain amount since young coconut and NHK endosperm are consumed directly or without processes. The coconut consumer will get 18 amino acids in different quantity as shown in table 1. Normally, Nam Hom mature nut is categorized as small nut, its price is very low, therefore, it's only suitable for young nut production. Although the young meat also has small amouth of fat content, the absorption for many elements and vitamins can be supported by coconut oil. It can be concluded that the benefit of consuming young tender nut is that the consumer will get amino acid and other electrolyte and vitamins with the absorption supported by coconut oil. The mineral content of young tender nut of Nam Hom varieties, analyzed from blended endosperm, consist of potassium, chloride, phosphorus, magnesium, calcium, and sodium at the amount of 2280.7, 851.8, 221.8, 148.4, 85.9, and 55.0 mg/kg, respectively (Twishsri, 2009).

Experiment II.

Although all coconut varieties can be used as raw material for VCO production, not all of them have high lauric acid content. Since the lauric acid is the major fatty acid in MCFA of coconut oil and it also the factor that attracts consumer's interest in VCO product. The quality of VCO is determined by the content of Medium Chain Fatty Acid (MCFA; C8:0 – C12:0) and lauric acid (Novarianto *et al*., 2006).

The second experiment aimed to determine fatty acid (FA) composition of coconut accessions in order to find out the coconut varieties that suit to be raw material for VCO production with high lauric acid content. The study found that the fatty acid composition of the VCO sample composed of high quantity of saturated FA; Medium-chain FA (MCFA) / having 8 to 12 carbon atoms such as Capryllic acid (C8:0), Capric acid (C10:0), Lauric acid (C12:0) with average of 5.9%, 5.5% and 48.9%, respectively. It also has a small amount of Long-chain FA (LCFA) which include both saturated and unsaturated FA having more than 12 carbon atoms such as Myristic (14:0) and palmitic (16:0) acids, stearic acid (18:0), Oleic acid (18:1 n-9) and Linolenic (18:2n-6) with the average of 19.8%, 9.5%, 3.3%, 6.5% and 1.2%, respectively. There were significantly differences on every single of those fatty acids (Table 2).

Coconut fats are easily digestable and not coagulate in the blood stream and not stored. MCFAs are not deposited in the adipose tissue but are readily oxidized in the body to provided quick energy favorable for use in sports nutrition and in slimming diet products (Kaunits (2001) cited by Ghosh *et al*, 2008). MCFA and medium-chain TAG (Triacrylglycerols) can pass directly into the portal vein and readily oxidized in the liver to serve as a source of energy rather than being absorbed through the lymphatic system. They are consequently a source of additional and quick energy for patients recovering from surgery or illness and for athletes. MCFA also increase metabolic rates and may serve as weight-loss ingredients in foods. They are used for enteral and parenteral nutrition and for patients suffering from fat malabsorption, maldigestion, and metabolic disorders. In infant formula, they enhance fat digestion and absorption**.** Hence, the proper ratio of fatty acid composition especially rich in lauric acid in coconut oil as well as VCO results in beneficial health aspects.

The ratio of fatty acid composition suits for clinical nutrition will compose of 30-65% Structured Lipids containing short chain FA and medium chain FA which functions as quick energy and rapid absorption, especially for immature neonates, hospitalized patients, and individuals with lipid mal absorption disorders (Akoh and Kim (2008) cited by Pande and Akoh, 2012). For that reason, coconut oil has been used for the media of various medicinal products and also for raw material for food supplement since

it has fatty acid composition fitted with specification of clinical nutrition. In addition, coconut oil, along with other fats, is used to mimic human milk, and infant milk powders containing coconut oil have been developed. MCT are essential nutrients for infants as well as for people with serious digestive problems such as cystic fibrosis because they are easily digested, absorbed, and put to use (Krishna, 2012). It was recommended that consuming 3-4 table spoons of VCO a day will provide enough lauric acid to build the immune system. Lauric acid has the additional beneficial function of being formed into monolaurin in the human or animal body (Nair, 2010).

The result from this study showed that the coconut varieties being studied have high lauric acid content in VCO (lauric acid $\geq$ 48.8%) and there is no significant difference among the mean of them at 5% level by DMRT. Theses varieties include Renell Tall, Chumphon Hybrid no.2, Malayan Yellow Dwarf, Sawi Hybrid no.1(MAWA), Hybrid Chumphon 60, Thai Red Dwarf, Sri Lanka Tall, and Hybrid Nam Hom x Kathi (NHK) with the lauric acid content 51.0, 50.1, 49.3, 49.0, 49.0, 49.0, 48.9, and 48.8%, respectively. These varieties, therefore, are suitable for VCO processing since they have high of lauric content when prcessed into VCO product.

Similar studies to this experiment have been done on 35 coconut accessions of Indonesian germplasm collection (25 Tall and 10 Dwarf coconut varieties) by Novarianto and others (2006). They found that the difference of lauric acid content between tall and dwarf coconuts was not too much, only about 2-3% and generally the content of MCFA of tall coconut was higher than that of dwarf coconut varieties. However, the results of this study show that the predominant varieties with high lauric acid content belong to both dwarf (e.g. Thai Red Dwarf and Malayan Yellow Dwarf) and tall of varieties and the average lauric content of all coconut group [(1) Local Thai Dwarf varieties, (2) Local Thai Tall varieties, (3) Foreign varieties, and (4) Hybrid varieties] is 48.1%. In addition, it can be observed from table 2 that the 2 VCO samples from Kaloke varieties [(10.1) the VCO sample from a group of tree producing large nut size and (10.2) the VCO sample from a group of tree producing big or extra large size nut] have no significant difference of the lauric acid value eventhough the samples are from different phenotype of nut.

The three hybrid varieties, issued by the Department of Agriculture: Sawi Hybrid No.1, Chumphon Hybrid No.2, and Hybrid Chumphon 60, have high lauric acid content, therefore, the result from this study can be used to support the promotion of planting of these hybrids as raw material of coconut milk and VCO processing industry.

Nam Hom varieties, the commercial young nut varieties of Thailand, has lauric acid content of 47.5% thus it is not suitable for VCO production. This is in line with the real situation in which its mature nut is categorized as small size and belongs to the cheapest priced group. The result in table 1 also support that the Nam Hom is suitable for commercial production of young tender nut for direct consumption since there are amino acids content in its meat (solid endosperm). The new hybrid NHK is still on high demand for Thai dessert, therefore, it is not recommended as raw material for VCO eventhough it has high lauric content. By direct consumption, it will benefit consumers because the fresh endosperm can provide them with both amino content and lauric content.

Conclusion

From this study, it can be concluded that the coconut meat of both young tender Nam Hom and mature NHK have higher amino acids content than coconut water. The coconut water of NHK at 12 months old has greater amount of amino acid. Therefore, it can be confirmed that consuming the Nam Hom at 7 months old and NHK at 12 months old will get high amino acids content. In addition, the information from this study could be used as nutritive label for commercial purpose.

The recommended coconut varieties for VCO production are: Na Like and Thai Red Dwarf from Thai Dwarf varieties group, Chumphon, and Kaloke from Local Thai Tall

Table 1. Amino acid content found in Nam Hom and NKH coconut varieties

Treatment	None Essential Amino Acids; mg/100g									Essential Amino Acids; mg/100g								
	Ala	**Arg**	**Asp**	**Cys**	**Glu**	**Gly**	**Pro**	**Ser**	**Tyr**	**His**	**Isoleu**	**Leu**	**Lys**	**Met**	**Phe**	**Thr**	**Try**	**Val**
T1	82.5	240.6	137.4 ab	60.9 ab	199.3	74.7	74.6	113.2 b	71.3	72.6 b	99.1 c	96.6	77.2 ab	43.2 bc	73.3 b	69.8	22.0	67.3
T2	139.5	218.5	232.0 b	219.0 b	201.0	105.0	35.5	115.0 b	54.0	68.5 b	81.0 bc	101.5	141.5 b	48.0 c	71.0 b	92.0	17.5	60.0
T3	109.4	157.4	17.6 a	45.0 a	206.2	61.6	23.8	45.5 ab	73.0	11.3 a	48.8 abc	89.6	71.7 ab	22.8 ab	32.4 ab	145.8	21.8	67.6
T4	26.8	16.8	14.0 a	7.4 a	14.4	23.7	3.7	21.3 ab	9.1	3.4 a	9.4 ab	10.2	10.2 a	6.3 a	4.8 a	16.7	1.8	8.7
T5	91.9	33.9	8.7 a	4.7 a	70.5	8.1	7.9	8.0 a	13.3	8.5 a	6.9 a	16.7	22.4 ab	2.4 a	4.6 a	148.9	5.5	7.2
mean	**86.5**	**127.4**	**71.2**	**56.6**	**133.8**	**51.0**	**28.6**	**56.7**	**43.4**	**30.3**	**46.8**	**60.2**	**59.1**	**22.8**	**34.7**	**94.8**	**13.4**	**40.9**
CV (%)	**97.0**	**96.6**	**108.0**	**140.9**	**114.8**	**125.5**	**131.4**	**78.6**	**126.1**	**63.1**	**71.6**	**101.6**	**95.2**	**49.0**	**72.8**	**164.9**	**121.6**	**92.0**
F-test	**F<1**	**ns**	*****	**ns**	**F<1**	**F<1**	**ns**	**ns**	**F<1**	******	*****	**ns**	**ns**	******	*****	**F<1**	**F<1**	**ns**

Mean in the same column followed by a common letters are not significantly different at 5% level by DMRT.
*ns refers to non significant, * refers to significant, **refers to highly significant.*

Noted: T1= coconut meat of NHK at 12 months old T2= coconut meat of young tender nut of Nam Hom at 7 months old
T3= coconut water of NHK at 12 months old T4= coconut water of young tender nut of Nam Hom at 7 months old
T5= coconut water of mature nut of Nam Hom at 11 months old.
None Essential Amino Acids such as Alanine, Arginine, Aspatic acid, Cystine, Glutamine, Glycine, Proline, Serine, and Tyrosine
Essential Amino Acids such as Histidine, Isoleucine, Leucine, Lysine, Methionine, Phenylalanine, Threonine, Tryptophan, and Valine

Table 2. Fatty Acid composition of VCO prepared from 20 coconut varieties

Coconut varieties	Capryllic acid	Capric acid	Lauric acid	Myristic acid	Palmitic acid	Stearic acid	Oleic acid	Linoleic acid
Thai Dwarf varieties								
1. Nam Hom	5.9 a-e	5.2 a-e	47.5 abc	20.7 de	9.4 b-e	3.1 a-d	6.7 bcd	1.2 ab
2. Nam Wan	5.6 a-e	5.1 a-d	46.9 abc	20.5 b-e	9.9 b-f	3.6 b-e	6.9 bcd	1.2 ab
3. Thai Red Dwarf	6.8 de	5.8 e-h	49.0 bcd	19.5 b-e	9.1 b-e	3.1 abc	6.6 bcd	1.3 a
4. Thai Brown Dwarf	5.2 abc	4.8 abc	45.3 a	21.1 e	11.2 f	4.2 e	6.8 bcd	1.1 ab
5. Maphrao Fai	4.8 ab	4.7 ab	45.6 a	20.1 b-e	10.8 ef	3.8 cde	8.5 e	1.4 b
6. Na Likae	4.6 a	4.6 a	48.2 a-d	19.9 b-e	10.0 c-f	3.6 b-e	7.6 de	1.4 b
Local Thai Tall varieties								
7. Chumphon	5.8 a-e	5.5 d-h	48.1 a-d	19.4 b-e	9.7 b-f	3.4 a-d	6.8 bcd	1.2 ab
8. Nakhon Sri Thamarat	5.2 abc	5.2 a-f	46.8 ab	20.6 cde	10.5 def	3.9 de	6.5 bcd	1.1 ab
9. Tap Sakae	5.9 a-e	5.5 d-h	47.5 abc	19.2 bcd	10.0 c-f	3.4 a-d	7.4 cde	1.2 ab
10.1 Kaloke (large nut)	6.4 b-e	5.8e-h	48.6 a-d	19.2 bcd	9.1 a-d	3.2 a-d	6.2 a-d	1.1 ab
10.2 Kaloke (extra large nut)	6.8 de	6.1 gh	48.6 a-d	18.7 ab	9.0 a-d	2.9 ab	6.3 a-d	1.3 b
11. Thalai Roi	5.8 a-e	5.3 b-f	46.8 ab	20.4 b-e	10.2 def	3.4 a-d	6.5 bcd	1.3 b
12. Pak jok	5.9 a-e	5.3 a-f	46.8 ab	20.1 b-e	10.0 c-f	3.4 a-d	7.2 b-e	1.3 b
Foreign varieties								
13. Malayan Yellow Dwarf	5.2 a-d	5.9 fgh	49.3 bcd	19.9 b-e	9.6 b-f	2.8 a	6.0 abc	1.2 ab
14. West African Tall	6.8 e	5.5 d-h	48.6 a-d	20.2 b-e	8.4 abc	3.1 abc	5.7 ab	1.2 ab
15. Sri Lanka Tall	6.1 a-e	5.4 c-g	48.9 bcd	20.1 b-e	8.9 a-d	3.0 ab	6.1 a-d	1.2 ab
16. Rennell Tall	6.5 cde	6.7 i	51.0 d	17.3 a	8.3 ab	3.2 a-d	5.9 abc	0.9 a
Hybrid varieties								
17. Sawi Hybrid No.1	6.3 b-e	5.6 d-h	49.0 bcd	20.2 b-e	8.4 abc	3.0 ab	6.1 a-d	1.3 b
18. Chumphon Hybrid No.2	6.7 cde	6.1 h	50.1 cd	20.4 b-e	7.4 a	2.7 a	4.8 a	1.4 b
19. Hybrid Chumphon 60	6.5 cde	5.9 fgh	49.0 bcd	18.9 abc	9.4 b-e	3.1 abc	5.9 abc	1.2 ab
20. Hybrid Nam Hom X Kathi (NHK)	6.1 a-e	5.8 e-h	48.8 a-d	19.0 a-d	9.2 a-e	2.9 ab	6.5 a-d	1.4 b
Mean	**5.9**	**5.5**	**48.1**	**19.8**	**9.5**	**3.3**	**6.5**	**1.2**
%CV	**13.4**	**6.3**	**3.4**	**4.5**	**9.0**	**12.3**	**12.2**	**14.7**
F-Test	*	**	*	**	**	**	**	**ns**

Mean in the same column followed by a common letters are not significantly different at 5% level by DMRT.
*ns refers to non significant, * refers to significant, **refers to highly significant.*

varieties group, Malayan Yellow Dwarf, West African Tall, Sri Lanka Tall, and Renell Tall from Foreign varieties group, and Sawi Hybrid no.1 (MAWA), Chumphon Hybrid no. 2, and Hybrid Chumphon 60 from Hybrid varieties group.

The findings of this study can be used by coconut breeder for varietal improvement in the future. The previously mentioned recommended coconut varieties should be selected as mother palms in breeding program. However, other factor like the annual production should be considered when we plant coconut as economic crop. Therefore, the Na Like and Thai Red dwarf varieties may not be recommended for planting as VCO raw material since its annual yield is rather low and their mature nuts are categorized in the group of small nut size was cheapest price when sold as raw material. Nevertheless, these two varieties can be recommended to coconut breeders and may be considered as female progenitors.

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Figure 1. A view of sample preparation at CHRC laboratory